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EVALUATION OF XM20 AND XM20E1 LANDING MATS UNDER HEAVY-DUTY LOAD

Carroll J. Smith

Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

December 1972

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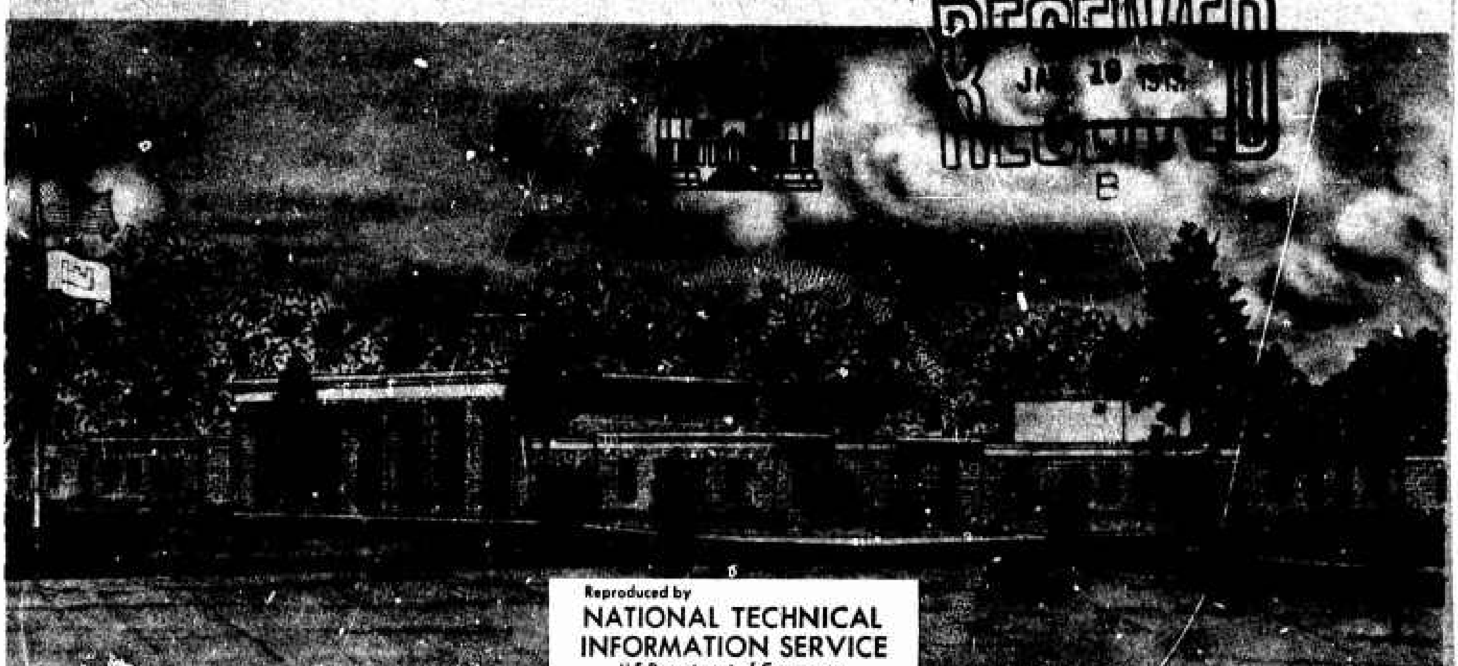

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Soils and Pavements Laboratory
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13. ABSTRACT

This report describes investigations conducted to evaluate two aluminum alloy landing mats manufactured by the Dow Chemical Company, Madison, Ill. These mats were designated as XM20 and XM20E1, and they are one-piece hollow extrusions fabricated from 6061 aluminum alloy artificially aged to the T6 condition. The XM20E1 mat is basically identical in design with the XM20 mat with the exception that geometrical changes in both male and female connectors were incorporated in the XM20 design to provide additional strength in these areas. Both the XM20 and the XM20E1 mats are interlocked along the sides by means of hinge-type connectors, the components of which are an integral part of the basic panel extrusion. End connectors are composed of extruded connectors welded to the basic panel and consist of an overlap and underlap section secured by a locking bar after individual panels have been joined together. These investigations consisted of traffic, skid, and laboratory tests to obtain information for use in evaluating the mats for potential use as heavy-duty landing mats. An AM2 repair panel was also included in the XM20 test in order to evaluate its performance under heavy-duty load conditions. The XM20 mat was also evaluated as a medium-duty mat in a previous investigation. The test data reported herein were evaluated against the criteria for heavy-duty mat as established in the revised Qualitative Materiel Requirement (QMR). Traffic tests were conducted with the mats placed on a prepared subgrade and trafficked with a rolling wheel load simulating actual aircraft operations. The XM20 and XM20E1 mats were assembled at an average rate of 445 and [illegible] sq ft per man-hour, respectively. These placing rates exceeded the minimum QMR rate of 150 sq ft per man-hour. The average weights of the XM20 and XM20E1 mats were 6.09 and 6.05 lb per square foot of placing area, respectively. The traffic tests were conducted with a 50,000-lb single-wheel load with a tire-inflation pressure of 250 psi on a mat-surfaced subgrade with initial average CBR's of 3.[illegible] and 4.0 for the XM20 and XM20E1 mats, respectively. Results indicated that when placed on a subgrade with a rated CBR of 4.0, the XM20 mat would sustain 610 coverages of traffic, and the XM20E1 mat would sustain [illegible]20 coverages. These results did not meet the QMR service life of 1000 coverages on a 4.0-CBR subgrade for a heavy-duty mat. The AM2 repair panel sustained 124 coverages on a subgrade with a CBR of 3.[illegible]. The average coefficients of friction obtained from wet and dry skid tests were 0.38 and 0.52, respectively, for the XM20 mat and 0.34 and 0.5[illegible], respectively, for the XM20E1 mat. The coefficients of friction on wet surfaces for both mats fell below the QMR coefficient of friction range of 0.4 to 0.[illegible]. The coefficients of friction of 0.38 and 0.52 for the XM20 mat were determined in a previous investigation wherein it was evaluated as a medium-duty mat. Laboratory tests conducted on both mats indicated that the 6061-T6 alloy exceeded the minimum physical requirements stipulated.

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FOREWORD

This report was prepared as a part of the work authorized by the Ground Mobility Division, Directorate of Research, Development, and Engineering, U. S. Army Materiel Command, under the title "Combat Engineer Equipment," DA Project No. 1G664717DH01 - Task 10 (formerly DA Project No. 1G664717D556 - Task 01, "Landing Mat Development").

The engineer design tests pertinent to these investigations were performed at the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., during August-September 1968 (XM20 mat) and June-July 1969 (XM20E1 mat) under the general supervision of Mr. J. P. Sale, Chief, Soils and Pavements Laboratory. Personnel of the Expedient Surfaces Branch actively engaged in the planning, testing, analyzing, and reporting phases of these investigations were Messrs. W. L. McInnis, H. L. Green, D. W. White, and C. J. Smith. The Flexible Pavement Branch had the responsibility for constructing and trafficking the test sections and also for performing the necessary soil tests under the supervision of Messrs. R. G. Ahlvin and C. D. Burns. This report was prepared by Mr. Smith.

Directors of the WES during the conduct of these studies and the preparation of this report were COL John R. Oswalt, Jr., CE, COL Levi A. Brown, CE, and COL Ernest D. Peixotto, CE. Technical Directors were Messrs. J. B. Tiffany and F. R. Brown.

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CONTENTS

CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT

British units of measurement used in this report can be converted to metric units as follows:

Multiply	By	To Obtain
inches	2.54	centimeters
feet	0.3048	meters
square inches	6.4516	square centimeters
square feet	0.092903	square meters
cubic feet	0.0283168	cubic meters
pounds (mass)	0.45359237	kilograms
pounds (force)	4.448222	newtons
pounds (force) per square inch	0.6894757	newtons per square centimeter
pounds (mass) per square foot	4.88243	kilograms per square meter
pounds (mass) per cubic foot	16.01846	kilograms per cubic meter
miles per hour	1.609344	kilometers per hour

SUMMARY

This report describes investigations conducted to evaluate two aluminum alloy landing mats manufactured by the Dow Chemical Company, Madison, Ill. These mats were designated as XM20 and XM20E1, and they are one-piece hollow extrusions fabricated from 6061 aluminum alloy artificially aged to the T6 condition. The XM20E1 mat is basically identical in design with the XM20 mat with the exception that geometrical changes in both male and female connectors were incorporated in the XM20 design to provide additional strength in these areas. Both the XM20 and the XM20E1 mats are interlocked along the sides by means of hinge-type connectors, the components of which are an integral part of the basic panel extrusion. End connectors are composed of extruded connectors welded to the basic panel and consist of an overlap and underlap section secured by a locking bar after individual panels have been joined together.

These investigations consisted of traffic, skid, and laboratory tests to obtain information for use in evaluating the mats for potential use as heavy-duty landing mats. An AM2 repair panel was also included in the XM20 test in order to evaluate its performance under heavy-duty load conditions. The XM20 mat was also evaluated as a medium-duty mat in a previous investigation. The test data reported herein were evaluated against the criteria for heavy-duty mat as established in the revised Qualitative Materiel Requirement (QMR).

Traffic tests were conducted with the mats placed on a prepared subgrade and trafficked with a rolling wheel load simulating actual aircraft operations. The XM20 and XM20E1 mats were assembled at an average rate of 445 and 617 sq ft per man-hour, respectively. These placing rates exceeded the minimum QMR rate of 150 sq ft per man-hour. The average weights of the XM20 and XM20E1 mats were 6.09 and 6.05 lb per square foot of placing area, respectively. The traffic tests were conducted with a 50,000-lb single-wheel load with a tire-inflation pressure of 250 psi on a mat-surfaced subgrade with initial average CBR's of 3.6 and 4.0 for the XM20 and XM20E1 mats, respectively. Results indicated that when placed on a subgrade with a rated CBR of 4.0, the XM20 mat would sustain 610 coverages of traffic, and the XM20E1 mat would sustain 620 coverages. These results did not meet the QMR service life of 1000 coverages on a 4.0-CBR subgrade for a heavy-duty mat. The AM2 repair panel sustained 124 coverages on a subgrade with a CBR of 3.6.

The average coefficients of friction obtained from wet and dry skid tests were 0.38 and 0.52, respectively, for the XM20 mat and 0.34 and 0.56, respectively, for the XM20E1 mat. The coefficients of friction on wet surfaces for both mats fell below the QMR coefficient of friction range of 0.4 to 0.8. The coefficients of friction of 0.38 and 0.52 for the XM20 mat were determined in a previous investigation wherein it was evaluated as a medium-duty mat.

Laboratory tests conducted on both mats indicated that the 6061-T6 alloy exceeded the minimum physical requirements stipulated.

EVALUATION OF XM20 AND XM20E1 LANDING MATS UNDER HEAVY-DUTY LOAD

PART I: INTRODUCTION

Background

1. The investigation and evaluation of the landing mats described herein comprise an engineer design test (EDT) in the U. S. Army Materiel Command's (AMC) continuous program for the development of satisfactory landing mats for use as expedient surfacing materials for forward-area airfields. The U. S. Army Engineer Waterways Experiment Station (WES) has been assigned the responsibility for the development of mats from metals and plastics.

2. The development of the extruded T8 magnesium mat[1] and the similarly designed extruded T11 aluminum mat indicated potential of a tremendous advance in the design of landing mats. In the extrusion process, metal can now be placed where it will do the most good, making it possible to design a mat of optimum efficiency. WES Technical Report No. 3-634,[2] dated September 1963, indicated the T11 mat to be superior to previously tested mats and prompted a limited field test of the modified T11 aluminum mat by the Air Force at England AFB, Alexandria, La., from December 1963 to July 1964. Results of these tests, reported in references 3 and 4, prompted the Air Force to formulate "Performance Requirements for Landing Mat," which was sent to AMC as an inclosure to a letter, subject: Development of Landing Mat, dated 8 October 1964. A Qualitative Materiel Requirement (QMR) for Prefabricated Airfield Surfacings, dated 14 April 1966, was approved using the loadings that evolved from the Air Force requirements. This QMR was subsequently revised and a new one approved on 2 April 1968.

3. The XM20 mat performed superlatively under medium-duty load conditions (5000+ coverages) as reported in WES Miscellaneous Paper S-69-28,[5] dated July 1969. The investigation reported herein was

conducted on the XM20 mat and an improved version of the XM20 mat, designated XM20E1, as well as on an AM2 repair panel* in accordance with the conditions set forth for heavy-duty type mat in the revised QMR dated 2 April 1968.

Objectives

4. The general objectives of this investigation were to evaluate both the design and the performance of experimental quantities of XM20 and XM20E1 landing mats to determine their suitability as heavy-duty expedient surfacing material for forward operating bases. The specific objectives of this investigation were to determine:

- a. The service life of the XM20 (including an AM2 repair panel) and XM20E1 mats when placed on a subgrade having a CBR of 4.0 and trafficked with a 50,000-lb** single-wheel load with a tire-inflation pressure of 250 psi.
- b. The average placement rates of the mats.
- c. The coefficients of friction of the mat surfaces.
- d. The structural properties of the mats.

Scope

5. This report describes and gives results of accelerated traffic tests conducted to evaluate the XM20 (including an AM2 repair panel) and XM20E1 extruded aluminum landing mats. Data for the evaluation were obtained as follows:

- a. Traffic tests were conducted on specially constructed test sections to study subgrade behavior and to observe the performance of the mats under a rolling wheel load.
- b. In laying the mats during the assembly of the test sections, the placement times were recorded and the placing rates computed.

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* An AM2 repair panel was included in the test in order to evaluate its performance under heavy-duty load conditions.

** A table of factors for converting British units of measurement to metric units is presented on page ix.

c. The force required to skid a loaded cart over the mats was recorded, and the coefficients of friction were determined.*

d. Laboratory tests were conducted to evaluate the physical and structural properties of the mats.

Definitions of Pertinent Terms

6. For information and clarity, definitions of certain terms used in this report are given below:

Test section. A prepared section on which the landing mat is placed for test purposes.

Traffic lane. Area of the test section that is subjected to the moving wheel load of the load cart.

Subgrade. The portion of the test section constructed with the soil processed under controlled conditions to provide the desired bearing capacity and upon which the landing mat is placed.

CBR (California Bearing Ratio). A measure of the bearing capacity of the soil based upon its shearing resistance. The CBR value is calculated by dividing the unit load required to force a piston into the soil by the unit load required to force the same piston the same depth into a standard sample of crushed stone and multiplying by 100.

Run. A strip of landing mat equal to one panel width and extending transversely across the entire test section.

Coverage. One application of the test wheel of the load cart over every point in the central portion of the traffic lane (see plate 4).

Pass. One traverse of a load wheel along a given length of runway, taxiway, or test section surface.

Load cart. A specially constructed item of equipment used in WES engineering tests for simulating aircraft taxiing operations.

Test wheel. The wheel on the load cart that supports the main load.

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* Skid tests on the XM20 mat reported herein were conducted in a previous investigation of the XM20 mat evaluated as a medium-duty mat. The skid test results are presented in reference 5.

Extrusions. Metal shapes produced by forcing cast billets, heated to a plastic condition, through a steel die opening of the desired cross section.

Direction of traffic. The direction in which the load cart travels on the test section. The direction of traffic is representative of actual landing directions with respect to panel joints.

Deflection. Temporary bending of landing mat panels under the static load from the test wheel of the load cart.

Dishing. Permanent bending of a panel either parallel or perpendicular to the direction of traffic.

PART II: DESCRIPTION OF MAT

Fabrication Features

7. The XM20 and XM20E1 landing mats were extruded aluminum alloy landing mats designed and extruded by the Dow Chemical Company, Madison, Ill. The mats were fabricated by the Washington Aluminum Company (WACO), Enterprise, Ala. (Dow's subcontractor).

XM20 mat

8. The XM20 mat panels are one-piece hollow extrusions with 12 internal vertical ribs. The panels (fig. 1), which are 1-1/2 in.

Fig. 1. XM20 landing mat panel

thick, 2 ft wide, and 12 ft long, were fabricated from 6061 aluminum alloy. The extrusions are artificially aged to the T6 condition, which involves solution heat treatment and oven cycling to produce a stable temper. The panels are interlocked along the sides by means of a hinge-type connector, the components of which are an integral part of the basic panel extrusion. Short tubes matching the inside contours of the mat extrusion are inserted into each cavity and welded flush with the ends of the basic extrusion. The extruded end connectors, consisting of an overlap and underlap section, are then welded to the basic

extrusion. A locking bar secures the end connectors after individual panels have been placed together. The top facings of the panels were treated with a conversion coating prior to application of the antiskid material. The antiskid material was developed by the W. P. Fuller Paint Company (now the Fuller-O'Brien Corporation).

XM20E1 mat

9. The XM20E1 landing mat panels are 1-1/2 in. thick, 2 ft wide, and 9 ft long (fig. 2). The 9-ft length was incorporated in order to

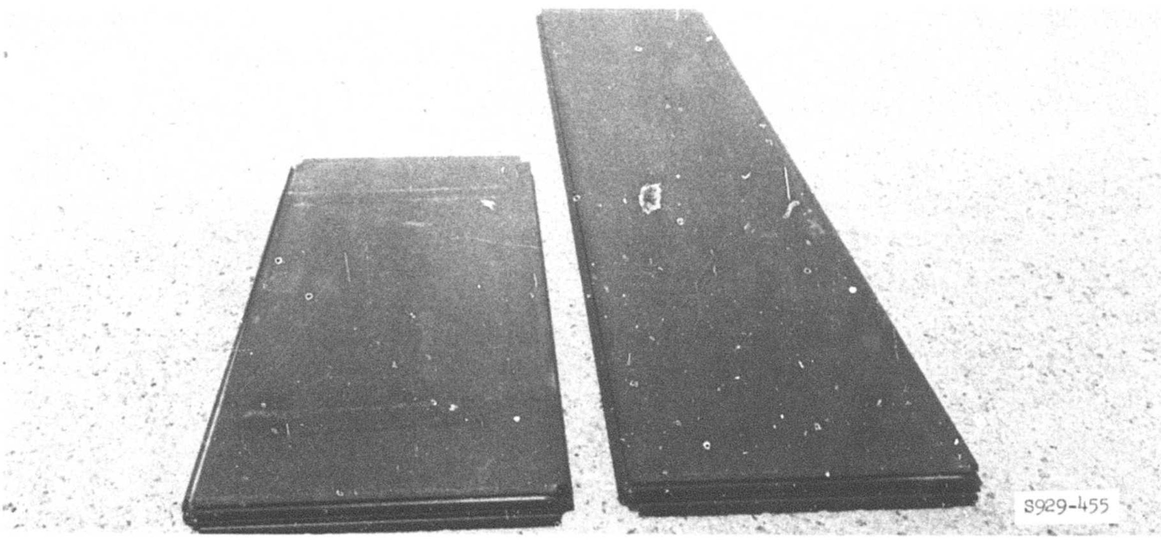


Fig. 2. Typical full and half panels of XM20E1 landing mat

meet the weight requirement set forth for heavy-duty mat in the revised QMR dated 2 April 1968. Geometrical changes in both male and female connectors were incorporated in the XM20E1 design (fig. 3) to provide

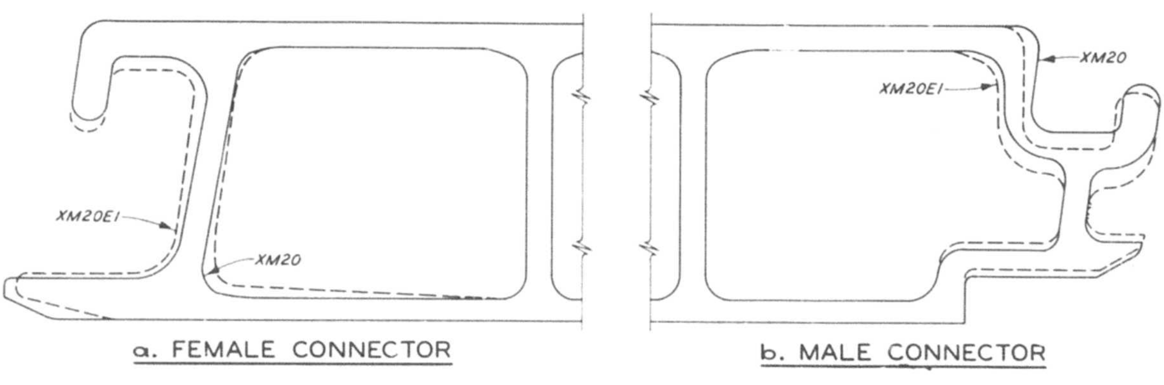


Fig. 3. Comparison of female and male connector geometry of XM20 and XM20E1 mats

additional strength in these areas; however, the extrusions are basically identical with the XM20 extrusions. The top facings of the panels were treated with a conversion coating prior to application of the antiskid material. The antiskid material was developed by the Fuller-O'Brien Corporation.

AM2 Repair Panel

10. A repair panel is a special panel that can be used to replace a single damaged mat panel within a mat field without removing adjacent panels. An AM2 repair panel (fig. 4) was used in the XM20 test section

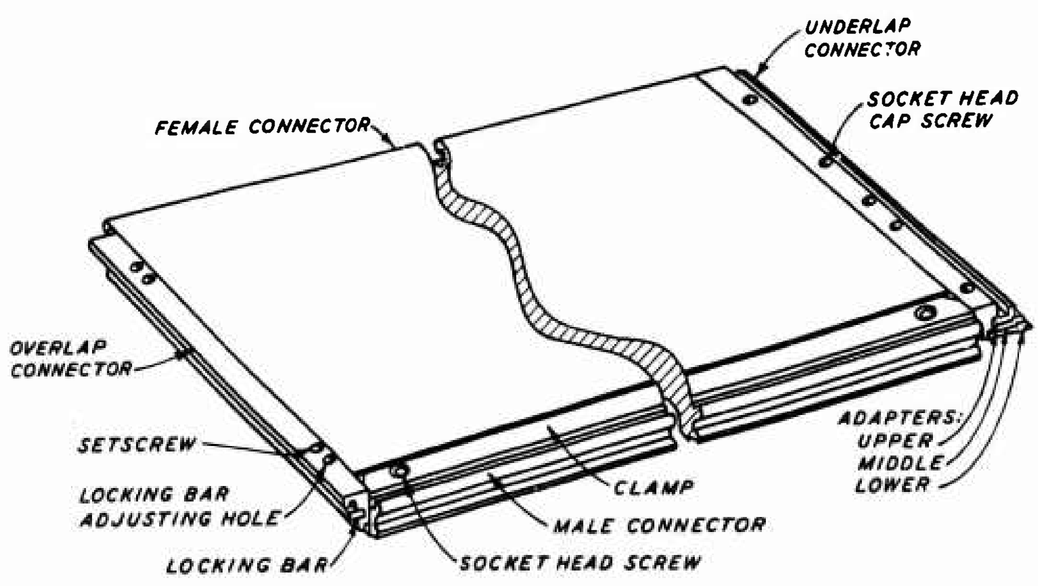


Fig. 4. AM2 repair panel

to evaluate its performance as a repair panel under heavy-duty load conditions. The overall outside dimensions of the panel are the same as those of the basic section of a regular XM20 panel, but other features are different. The repair panel weighs approximately 170 lb. The overlap connector is similar to the overlap connector on a standard panel except that the locking bar slot is deep enough for the locking bar to be completely recessed into it. The bar is held in the slot by two setscrews. Two access holes in the connector allow the bar to be worked out to lock the repair panel and the adjacent panel together

once the repair panel has been placed and the setscrews loosened. The male and underlap connectors consist of several parts separate from the repair mat extrusion. These parts are interlocked with the adjacent panel of mat prior to placement of the main body of the repair panel. The repair panel is then put into place, and its parts are connected to the main body with cap screws, thus completing the panel.

Physical Dimensions

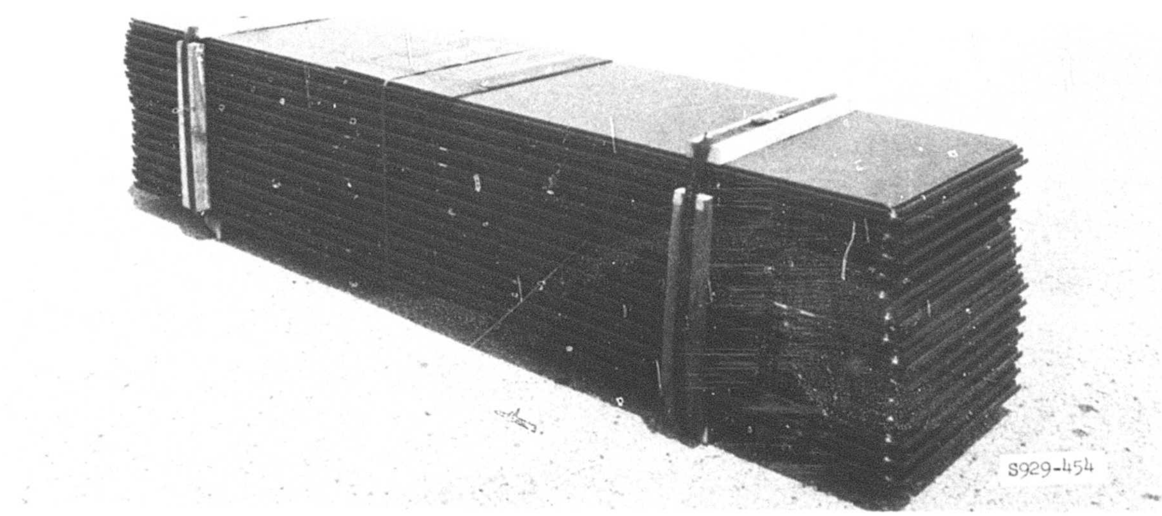
11. The XM20 and XM20E1 mats were shipped in bundles of either full or half panels (fig. 5). The method used for bundling the mats was not representative of that used for overseas shipment. Individual panels and bundles were weighed and measured, and average weights and dimensions are as follows:

Panels

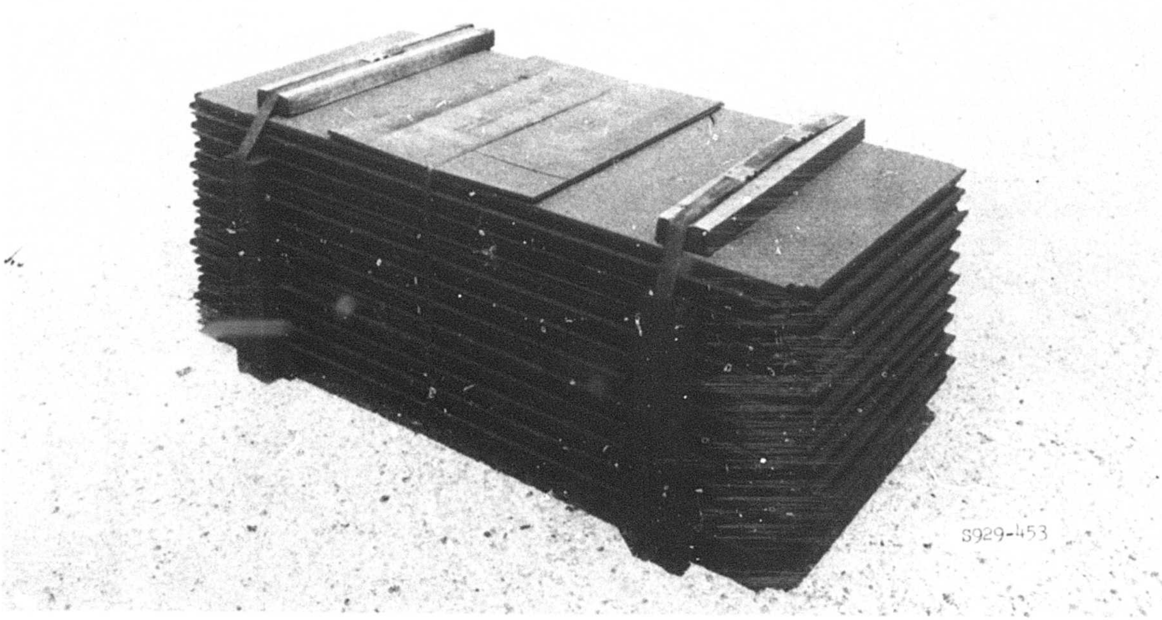
Type	Length in.	Depth in.	Width, in. Overall	Width, in. Placing	Placing Area per Panel sq ft	Weight lb	Weight per sq ft of Placing Area lb
XM20	145.02	1.5	24.75	24	24	146.15	6.09
XM20E1	109.00	1.5	24.75	24	18	108.90	6.05

Bundles

Type	Length ft	Width ft	Depth ft	Volume cu ft	Weight lb	Total Placing Area sq ft	No. of Panels	Volume per 100 sq ft of Placing Area cu ft
XM20	12.08	2.31	1.80	50.23	1610	264	11	19.03
XM20E1	9.09	2.33	2.19	46.38	1550	252	14	18.40

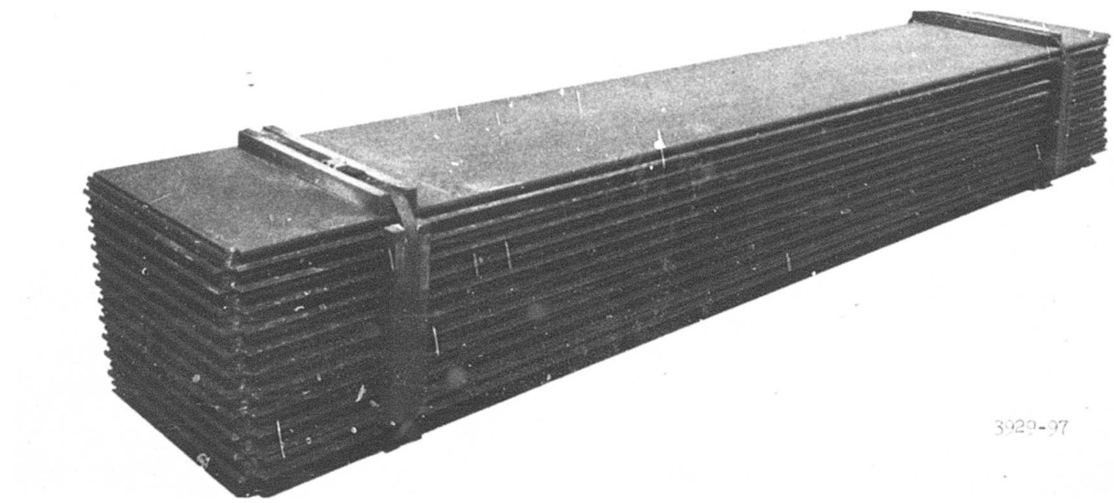


a. Full panels of XM20E1

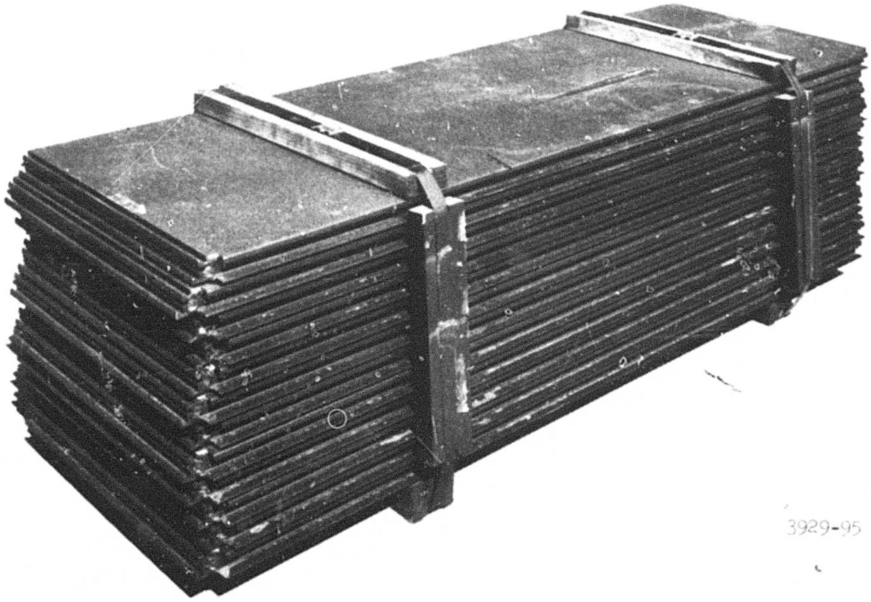


b. Half panels of XM20E1

Fig. 5. Bundles of mat panels (sheet 1 of 2)



c. Full panels of XM20



d. Half panels of XM20

Fig. 5. (sheet 2 of 2)

PART III: TEST SECTIONS, EQUIPMENT, AND PROCEDURES

Test Sections

12. The test areas were located under a hangar-type structure to provide both protection from the elements and the conditions necessary for accurately controlled traffic tests. Both test sections were excavated to a depth of 24 in. below the final grade and backfilled with four 6-in.-thick compacted lifts of a heavy clay (CH)[6] having an average liquid limit of 58 and an average plasticity index of 33 (plate 1). After backfilling was completed, the test sections were graded to provide smooth surfaces with no transverse grade. CBR, moisture content, and density tests were made during construction to ensure that the desired soil strengths were obtained. The initial average CBR's of the subgrades for the XM20 and XM20E1 test sections were 3.6 and 4.0, respectively. Soil data for the test sections are shown in table 1.

13. The XM20 and XM20E1 test sections were 40 ft long and 36 ft wide and 40 ft long and 27 ft wide, respectively, with an 11-ft-wide traffic test lane in the longitudinal center of the test sections (plates 2 and 3). An approach area was provided at each end of each test section to maneuver the load cart in the application of traffic. Joints of panels were staggered to produce a pattern similar to brickwork construction; half panels were used along the edges of the test sections to obtain this pattern. Individual panels in the test lanes were numbered consecutively to identify the panels subjected to traffic. Lead weights of 2000 lb each were used to anchor the panels at the sides of the test sections in lieu of earth anchors.

Mat Placement

14. Placement of the panels on the test sections was accomplished by an experienced crew of six men under the direction of a foreman. The mats were stacked adjacent to the test section in open bundles to minimize the distance panels had to be hand-carried by the placing crew.

A forklift was used to maneuver the bundles in order to keep them as close to the placing crew as practical. The operator's time was not included in the placing rate computations. Assembly of the panels into a test section was accomplished by hinging the female connector of a panel with the male connectors of panels previously in position and then dropping the panels into position. The end connectors were mated by overlapping and were secured by an end-connector locking bar that was slid into position. An AM2 repair panel was installed in the XM20 test section (plate 2) according to mat placement procedures for repair panels. Individual and multiple mat replacement procedures are reported in WES Instruction Report S-69-3, "Installation of XM18 Extruded Aluminum Airfield Landing Mat."[7] The approach areas to the XM20E1 test section were composed of used XM20 and XM18 mats. During placement of the XM20E1 mats, the XM20E1 female connectors would not connect with the XM20 or XM18 male connectors, but the XM20E1 male connectors would connect with the XM20 or XM18 female connectors; therefore the XM20E1 mats at the "female" end of the test section were secured to the approach mats with special adapters.

15. The seven-man crew placed the XM20 and XM20E1 mats at an average rate of 445 and 617 sq ft per man-hour, respectively.

Test Load Cart

16. Traffic was applied with a load cart (fig. 6) utilizing a single wheel mounted in its load box. Independent action of the outrigging and the load box of the test rig made possible a constant load on the outrigger wheels and a variable loading on the test wheel. The test wheel was loaded to 50,000 lb, and the 56x16 tire was inflated to 250 psi. A 24-ply tire with a contact area of 216 sq in. and an average contact pressure of 232 psi was used on the XM20 test section, and a 32-ply tire with a contact area of 219 sq in. and an average contact pressure of 228 psi was used on the XM20E1 test section.

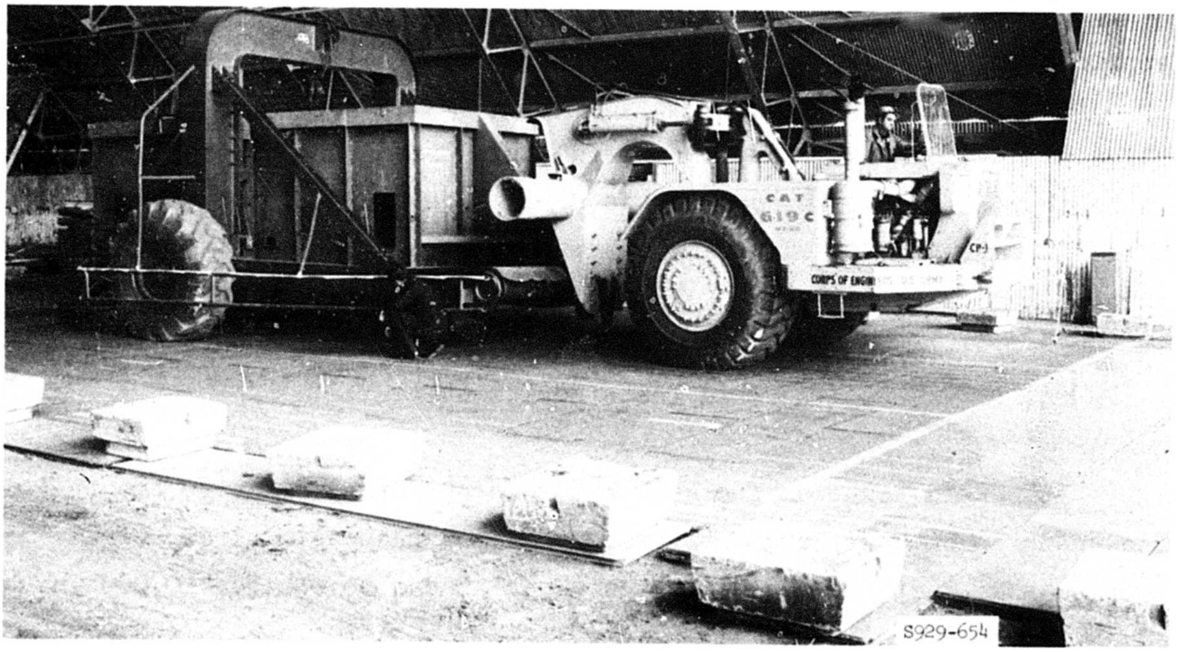


Fig. 6. Load cart used in accelerated traffic tests; 50,000-lb single-wheel load and 250-psi tire pressure

Application of Traffic

17. Traffic was applied to simulate the traffic distribution pattern that would be encountered in actual aircraft takeoffs and landings. This pattern approaches a statistically normal distribution curve.[8,9] Traffic was started at one side of the traffic lane, and the load cart was driven forward and then backward in the same path for the length of the test section. The path of the cart was shifted laterally 12 in. (the width of a tire print) on each successive forward trip. Thus, two coverages of the entire traffic lane were accomplished when the load cart had maneuvered from one side of the traffic lane to the other. The interior 108 in. of the traffic lane was then trafficked for six additional coverages. The longitudinal center 60 in. of the traffic lane received two additional coverages for a total of ten coverages. The net result was that the center 60-in.-wide strip of the traffic lane received 100 percent of the traffic, the 24-in.-wide strips on each side

of the center 60 in. received 80 percent, and the two 12-in.-wide edge strips received only 20 percent (plate 4). This pattern of traffic application was repeated until mat failure occurred.

18. Single-line traffic consists of load repetitions that are applied in a single path (one-tire-print width) and that are referred to as passes. Single-line traffic was applied to the XM20 mat (plate 2) after the mat had failed with the traffic applied as described in paragraph 17.

Skid Tests Equipment

19. Skid tests on the XM20 mat were performed prior to the traffic tests on both dry and wet surfaces with a pneumatic-tired, two-wheeled skid cart (fig. 7). The cart was loaded to achieve 10,000 lb

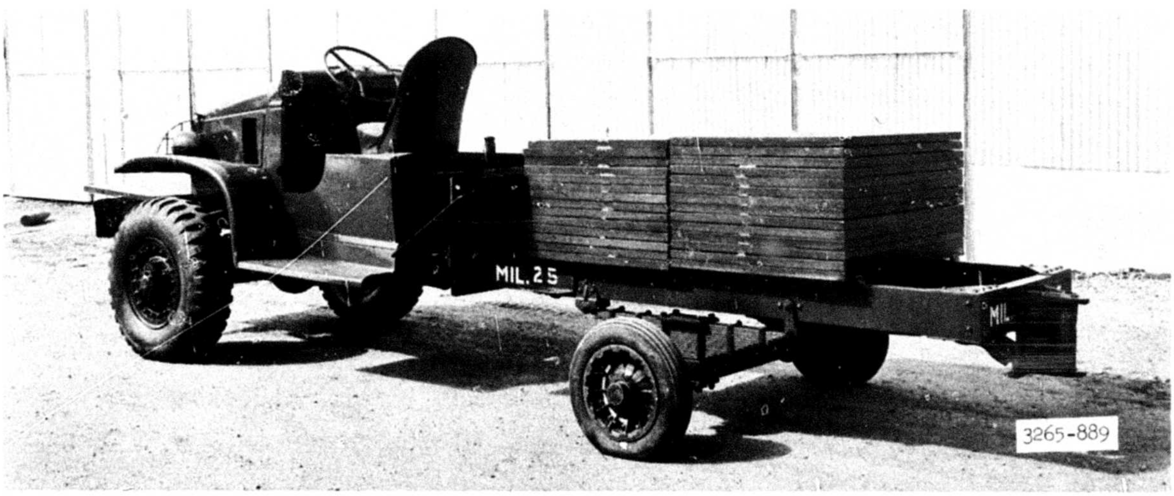


Fig. 7. Skid cart used in skid-resistance and tire-wear tests on XM20 mat

on each rear wheel, and the tires were inflated to 200 psi. Two 26.00x6.6 tires, each with a contact area of 53 sq in. and an average contact pressure of 190 psi, were used on the skid cart. The truck section of the skid cart was used for steering, and a tractor was used to pull the skid cart.*

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* Skid tests on the XM20 mat evaluated as a medium-duty mat were conducted prior to the skid tests reported herein. The skid cart description and skid test results are also presented in reference 5.

20. Skid tests on the XM20E1 mat were performed prior to the traffic tests on both dry and wet surfaces with a C-130 skid cart loaded to achieve 30,000 lb on a wheel with a 20.00x20.00, 20-ply tire inflated to 100 psi (fig. 8). The truck section of the skid cart was used for

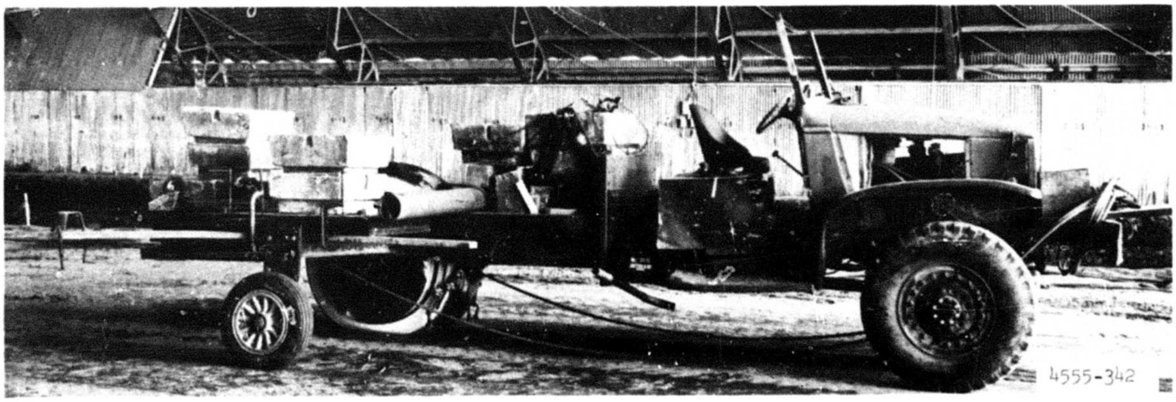

Fig. 8. C-130 skid cart used in skid-resistance and tire-wear tests on XM20E1 mat

steering, and a Tournadozer was used to pull the skid cart.

21. To perform the tests, each skid cart was positioned along one side of the traffic lane with the wheel(s) locked to prevent rotation. The cart was skidded over the mat at a uniform speed for a given distance to determine the skid resistance offered by the mat surface and the tire wear resulting from the skidding. The force required to pull each skid cart over the mat surface with the wheel(s) locked was measured with an electric recording dynamometer of 50,000-lb capacity.

PART IV: CRITERIA FOR MAT FAILURE AND DATA TAKEN

Failure Criteria

22. The following guidelines were used to determine mat failure:

a. Excessive mat breakage.

(1) Weld failure: when the weld failure appreciably affects the performance of the mat or becomes a tire hazard.

(2) Rib failure: when the rib failure appreciably affects the performance of the mat or causes undue roughness.

(3) End-joint failure.

(4) Breaks.

(a) A panel was considered failed when a break was considered to be a tire hazard.

(b) A section was considered failed when breaks exceeding 6 in. in length occurred in 50 percent of the panels, or when breaks extending 40 percent of the length of a panel occurred in 20 percent of the panels.

b. Static deflection, 1 in. maximum.

c. Roughness.

(1) Deflection not to exceed 1 in. at side joint. Measurement to be made from a 4-ft-long straightedge.

(2) Dishing not to exceed 0.6 in. measured from a 2-ft-long straightedge.

(3) Uneven mat surface and instability of the test vehicle as determined by visual observations and experienced judgment when the test vehicle was traveling at a uniform speed (approximately 2 to 4 mph).

23. It was assumed that a certain amount of maintenance would be performed in the field during usage of the mat. For engineer traffic tests, the total number of panels that can be replaced in the traffic lane is equal to 10 percent of the number of panels receiving 100 percent of traffic. When an additional panel required replacement or was considered a tire hazard, the section was considered failed.

Types of Data Recorded

Skid tests

24. Recordings of the force required to pull the skid cart and of the distance of the skid were made on individual oscillograms. Comparative tire wear was estimated by visual observations supplemented by photographs. Observations and photographs of the antiskid coatings on the mat were made before and after the skid tests.

Traffic tests

25. In-place subgrade densities, water contents, and CBR's measured before, during, and after the traffic tests are shown in table 1; the locations of these measurements are shown in plates 2 and 3. These soil tests were made at the surface of the subgrade and at depths of 6 and 12 in., with a minimum of three values at each depth. Static deflections of the mats were measured under the load wheel at the joints, quarter points, and center points of panels, and results are shown in plates 5 and 6. Level readings (transverse and longitudinal) were taken before and during traffic to measure permanent deformation of the test section and to reveal the development of roughness. These readings are shown in plates 7-10. Visual observations of the mat, subgrade behavior, and other relevant factors were recorded throughout the period of traffic and were supplemented by photographs. Pertinent data will be discussed later in this report.

PART V: TEST RESULTS AND ANALYSIS

Test Results

Skid tests

26. The present QMR* specifies that landing mat surfaces must provide effective braking with a Runway Condition Reading (RCR)** of 13 to 25 for aircraft operations on a wet or dry surface. This range of RCR corresponds approximately to a coefficient of friction range of 0.4 to 0.8.

27. XM20 mat. Since skid tests had been conducted on XM20 mat evaluated as medium-duty mat,[5] repeated skid tests on identical XM20 mat were not warranted. The average coefficients of friction on dry and wet surfaces in these tests were 0.52 and 0.38, respectively. Tire wear on the wet surface was negligible, but slight wear resulted from skidding on the dry surface.

28. XM20E1 mat. Average forces of 16,800 and 10,150 lb were required to skid the cart over dry and wet mat surfaces, respectively. The coefficients of friction for these data are:

$$\text{Dry:}\quad \frac{16{,}800}{30{,}000} = 0.56$$

$$\text{Wet:}\quad \frac{10{,}150}{30{,}000} = 0.34$$

Skid marks on the dry and wet mat surfaces (photo 1) show that the antiskid material did not flake or peel during these tests. Tire wear on both dry and wet surfaces was considered scant since only small pieces of rubber were torn from the tire.

Traffic tests

29. XM20 mat. The average CBR of the subgrade at the start of traffic was 3.6 (table 1), and the mat surface was generally smooth

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* Revised Department of Army Approved Qualitative Materiel Requirement (QMR) for Prefabricated Airfield Surfacings, April 1968.

** The RCR is an index of surface slickness measured by a special decelerometer.

(photo 2). After 10 coverages of traffic, slight curls of the top lips of the female connectors at the female/overlap and female/underlap corners of all mats had occurred. A 5/8-in. break had developed in the weld between the extrusion and the underlap connector at the female/underlap corner of the AM2 repair panel after 22 coverages (photo 3). The curls of the female/end connector corners of the XM20 panels increased slightly until 40 coverages; thereafter, the curls did not show a significant increase until nearer the end of the test. The two edge screws on the underlap connector of the repair panel had stripped from the lower adapter of this connector after 54 coverages, allowing some separation between this panel and panel 2. After 124 coverages the repair panel was considered failed due to the curl at the female/underlap corner (photo 4). The three center screws in the underlap connector were separated from the top part of this connector, and the two end screws were stripped out. The curl and the separations were considered a tire hazard. The positions of panels 1 and 2 were interchanged in the test section to move the tire hazards outside the traffic lane, and traffic was continued.

30. At the completion of 200 coverages, the repair panel and panel 2 had separated again (photo 5). A 1-1/2-in.-long break in the weld between the overlap connector and the extrusion of the repair panel was present along with a 3-in. split in the female connector lip of panel 2. These conditions constituted a tire hazard; however, panel 2 was not considered part of the test section for failure percentage purposes, since the failure of the repair panel caused this panel to fail. The repair panel and panel 2 were removed from the test section and were replaced with AM2 panels. Panel 3 was damaged on the male connector at the end joint of the repair panel and panel 2, and this panel was replaced with a new XM20 panel, 3A.

31. After 276 coverages, panel 25 was considered failed due to the separation from panel 26 at the end joint. After panel 26 was removed from the test section, it was seen that the top lip of the underlap connector of panel 25 was partially broken off, allowing the separation (photo 6). This separation caused the female connector of panel 24

to split at the center of the panel (photo 6). Panel 24 was replaced with a new XM20 panel, 24A; the positions of panels 25 and 26 were interchanged in the test section; and traffic was continued.

32. At the completion of 370 coverages, panel 13 was considered failed due to separation from panel 14 (photo 7). This separation was similar to the separation of panels 25 and 26. The female connector lip contained a 2-in. split (see photo 7). A 29-in. split was noted at the center of panel 12 in the bottom flange of the female connector when panels 13 and 14 were removed and their positions interchanged. After 384 coverages, panel 16 was considered failed due to separation from panel 17 (photo 8). It was noted that panel 15 contained an 18-in. split in the center of the panel in the bottom flange of the female connector when the positions of panels 16 and 17 were interchanged.

33. After 400 coverages, panel 28 was considered failed due to the separation at the end joint of panels 28 and 29 (photo 9). Due to failure of panels in excess of 10 percent of the number of panels in the 100-percent traffic area and because curls at the end joints of the female connector top lips presented tire hazards (photo 10), the test section was considered failed at 400 coverages (photo 11). Mat deformation of 1-1/2 in. was measured from an 11-ft straightedge placed perpendicular to the direction of traffic. Static deflection data recorded at the end joints of panels 10 and 11 and 22 and 23, the quarter points of panels 8 and 20, and the center points of panels 9 and 21 are shown in plate 5. Cross-section and permanent deformation profile curves are shown in plates 7 and 9, respectively. The average CBR at the completion of the test was 3.7, and the rated CBR for the test section was 3.6 (table 1).

34. At this point, 680 passes of traffic were applied along a single line on the west side of the traffic lane (plate 2) in the 80-percent traffic area in order to evaluate the cross-sectional geometry of the mat. Thus, a cumulative total of 1000 passes had been applied to this portion of the traffic lane (680 + 80 percent of 400 or 680 + 320). No breaks or tears were noted, and only slight dishing (less than 1/16 in.) was measured.

35. XM20E1 mat. Prior to the application of traffic, the mat

surface was generally smooth (photo 12), and the average in-place CBR was 4.0 (table 1).

36. After 150 coverages, the male and female connectors on panel 7 deflected downward beginning 3 in. from and parallel to the male and female connectors, which gave the panel a reverse dish appearance. After 350 coverages, similar reverse dishing was observed on panels 17 and 42. However, the test section was relatively smooth at the completion of 500 coverages (photo 13). Static deflection, cross-section, and permanent deformation data are shown in plates 6, 8, and 10, respectively. Since the strength of the subgrade had increased to a CBR of 5.2 after 500 coverages (table 1), the mat was removed from the test section, and the subgrade was reprocessed.

37. The average CBR of the reprocessed subgrade was 3.6 (table 1). All panels were relaid in their original positions on the test section. At 630 coverages, an 8-in. break on the panel surface had developed 1 in. from and parallel to the male connector along the center of panel 2 (photo 14). After 650 coverages, cracking of the antiskid coating of panels 27, 37, 42, and 47 indicated imminent development of panel surface breaks similar to the break in panel 2. At 650 coverages, panel 32 had developed an 8-in. surface break 1 in. from and parallel to the male connector, and by 730 coverages, the break had increased to 22 in. (photo 15). Panels 2, 7, 12, 22, 27, 32, 37, 42, and 47 had developed breaks of various lengths, all of which paralleled the male connectors and occurred on the male sides in the center of the panels.

38. After 780 coverages, the test section was considered failed (photo 16). Failure was attributed to tire hazards resulting from surface breaks and from sheared lips on the end connectors, which left the corners of these connectors exposed. The sheared lips on the end connectors allowed the panels to separate as the load wheel moved in the vicinity of the damaged joints. Four joints along the center of the traffic lane contained sheared lips on the end connectors that were considered tire hazards. Photo 17 shows a surface break on panel 32 that had progressed to 38 in. and a surface depression of 5/16 in. This photograph also shows the exposure of the overlap corner of panel 39 due

to the bottom lip of the panel being completely sheared off. Photo 18 shows a surface break on panel 47 and the sheared top lip of the underlap connector of panel 50 that caused panels 49 and 50 to separate. Using an 11-ft straightedge, deformation measurements were made perpendicular to the direction of traffic on each run of mat. The average deformation on the even- and odd-numbered runs was 1.58 and 1.35 in., respectively. Static deflection data recorded at the end joints of panels 9 and 10 and 34 and 35, the quarter points of panels 14 and 39, and the center points of panels 12 and 37 are shown in plate 6. Cross-section and permanent deformation profile curves are shown in plates 8 and 10, respectively. The CBR at the completion of the test was 4.2, and the rated CBR for the test section was 3.9 (table 1).

Analysis of Results

XM20 mat

39. Static deflection measurements were made with the test wheel positioned at the end joints of panels 10 and 11 and 22 and 23, the quarter points of panels 8 and 20, and the center points of panels 9 and 21 (plate 5). The maximum increase in static deflection from the beginning to the end of traffic was 0.5 in., which occurred at the quarter point of panel 8 and the end joint of panels 10 and 11. The maximum changes in cross-section (plate 7) and profile (plate 9) measurements from the beginning to the end of traffic were 1.2 and 1.6 in., respectively.

40. All panels were inspected after they had been removed from the test section. Nine panels contained splits in the center of the panel at the bottom flange of the female connector similar to the one shown in photo 19. Three panels contained breaks in the top lip of the underlap connector. There were no breaks in the bottom surfaces of the mat. Photo 20 shows metal wear and mar on the male connector which was typical of damage where an adjacent run of mat formed a joint.

XM20E1 mat

41. Static deflection measurements were made with the test wheel

positioned at the end joints of panels 9 and 10 and 34 and 35, the quarter points of panels 14 and 39, and the center points of panels 12 and 37 (plate 6). The maximum increase in static deflection from the beginning to 500 coverages of traffic was 0.6 in., which occurred at the end joint of panels 9 and 10. The maximum changes in cross-section (plate 8) and profile (plate 10) measurements from the beginning to 500 coverages were 1.3 and 1.4 in., respectively. The maximum increase in static deflection from 500 coverages (after subgrade reprocessed) to 780 coverages was 0.85 in., which occurred at the quarter point of panel 14 (plate 6). The maximum changes in cross-section (plate 8) and profile (plate 10) measurements from 500 coverages (reprocessed) to 780 coverages were 1.9 and 2.0 in., respectively.

42. After the panels had been removed from the test section, they were inspected. Nine panels contained surface breaks parallel to the male connector along the center of the panels where the adjacent run of panels formed a joint. Three of these nine panels contained breaks on the bottom surface as shown in photo 21. Eight panels had breaks in the top lip of the underlap connector; three panels contained breaks in the bottom lip of the overlap connector as shown in photo 22.

43. Several panels were sawed for inspection and dimensional measurements. All the measured thicknesses of the top sheet were under nominal and those near the male connector were minimum. The rib thicknesses were a maximum at the center of the extrusion, and all bottom sheet thicknesses were above nominal. However, these dimensions were all within allowable tolerances.

<u>Mat strength evaluation</u>

44. The rated CBR, total single-wheel load, tire pressure, and number of coverages at failure were substituted in the equation*

$$\frac{t}{0.23 \log_{10} (C) + 0.15} = \sqrt{P\left(\frac{1}{8.1\ \mathrm{CBR}} - \frac{1}{p\pi}\right)}$$

* This is a combination of equation 2, page 2, and the equation for the slope of the curve in plate 3, from reference 10.

where

t = design thickness of pavement structure, in.

C = coverages at failure (400)

P = total wheel (or equivalent single-wheel) load, lb (50,000)

CBR = rated California Bearing Ratio of subgrade (3.6)

p = tire pressure, psi (250)

to solve for t . Once t had been determined, the required CBR of 4.0 and the t , P , and p values were substituted in the above equation to solve for the number of coverages C that the XM20 mat would withstand. These computations indicated that the XM20 mat on a 4.0-CBR subgrade would withstand 610 coverages of traffic when subjected to a 50,000-lb single-wheel load with a tire-inflation pressure of 250 psi.

45. In order to evaluate the XM20E1 mat, it was necessary to assign a rated CBR for the initial and reprocessed subgrades to derive the predicted coverage level of the mat placed on a 4.0-CBR subgrade. The following tabulation is a summary of coverages and CBR's for the XM20E1 mat test and gives the equivalent coverages on a 4.0-CBR subgrade.

Subgrade	No. of Coverages Applied	Rated CBR of Subgrade	Equivalent Coverages on 4.0-CBR Subgrade
Original	500	4.6	295
Reprocessed	280	3.9	325
		Total	620

Computations indicated that the XM20E1 mat on a 4.0-CBR subgrade would withstand 620 coverages of the 50,000-lb single-wheel load with a tire-inflation pressure of 250 psi. A graphic interpretation of the strength evaluation of both mats, showing the service life in coverages that could be expected under various CBR strengths, is shown in plate 11.

PART VI: LABORATORY TESTS

Test Equipment

46. Laboratory tension tests were performed on Instron testing equipment with a 10,000-lb tension load cell capacity. The other laboratory tests were performed on 60,000-lb capacity Tinius Olsen and Southwark Tate-Emery testing machines.

Tests and Results

Tension tests

47. Tension tests were conducted to determine the tensile strength of the 6061-T6 alloy used in the fabrication of the XM20 and XM20E1 mats (table 2). The average ultimate tensile strengths determined for the top and bottom facings and the internal ribs of the XM20 and XM20E1 material were 45,062 and 44,742 psi, respectively. The average elongation determined for the XM20 material was 16 percent as compared to 12 percent for the XM20E1 material. Both strength and elongation values for the 6061-T6 alloy exceeded the requirement of 38,000-psi ultimate tensile strength and 8 percent elongation as specified in reference 11.

Beam tests

48. Beam tests were conducted on 60-in. specimens of XM20 and XM20E1 to determine their flexural strength. The individual specimens were arranged in the test machine as shown in fig. 9. Equal, concentrated loads were applied at the quarter points of the beam span as shown in the loading diagram, plate 12. During the test, load readings were obtained at 0.5-in. midspan deflection increments. These values were recorded and later reduced to a total-load-per-foot-of-width basis for comparisons of XM20 and XM20E1 mat. The results (plate 12) show that both mats supported approximately the same load with corresponding deflections up to 13,200 lb per ft of width. At higher loads, the

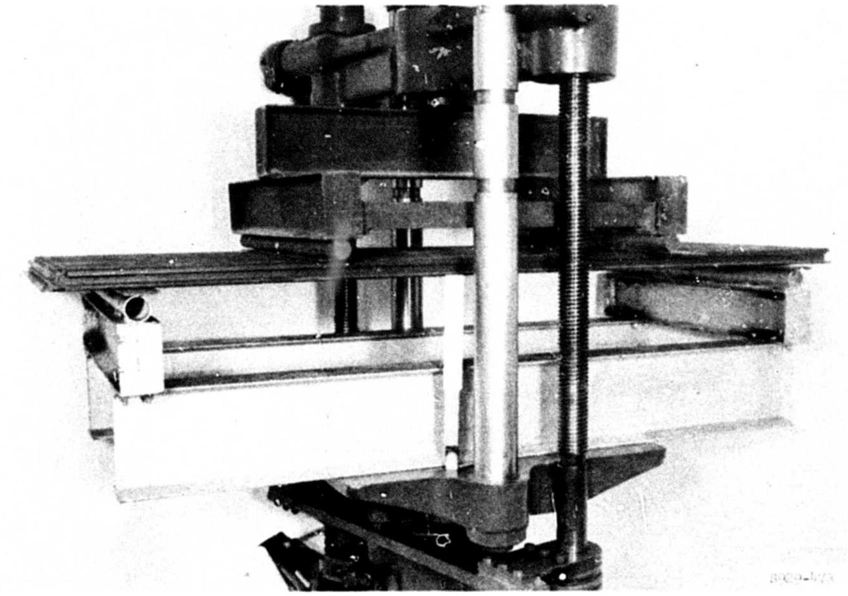

Fig. 9. Test setup for 60-in. beam tests

load per foot of width for the XM20E1 mat was greater than that of the XM20 mat at comparable deflections.

PART VII: SUMMARY OF RESULTS AND CONCLUSIONS

Results

49. Results obtained from this investigation of the 2- by 12-ft experimental landing mat are:

- a. The placement rate of the XM20 mat was 445 sq ft per man-hour on a flat surface.
- b. The XM20 mat as fabricated will support 610 coverages of a 50,000-lb single-wheel load on a subgrade with a CBR of 4.0.
- c. Laboratory-determined properties of the 6061-T6 alloy XM20 mat exceeded the specified mechanical properties for this alloy.
- d. The AM2 repair panel will support 124 coverages of a 50,000-lb single-wheel load on a subgrade with a CBR of 3.6.

50. Results obtained from this investigation of the XM20E1 2- by 9-ft experimental landing mat are:

- a. The placement rate of the mat was 617 sq ft per man-hour on a flat surface.
- b. The mat as fabricated will support 620 coverages of a 50,000-lb single-wheel load on a subgrade with a CBR of 4.0.
- c. The coefficients of friction for wet and dry surfaces were 0.34 and 0.56, respectively.
- d. Laboratory-determined properties of the 6061-T6 alloy XM20E1 mat exceeded the specified mechanical properties for this alloy.

Conclusions

51. Based on the results obtained from the investigation of the XM20 and XM20E1 mats, the following conclusions are believed warranted:

- a. Both XM20 and XM20E1 mats can be placed at a rate exceeding the minimum QMR rate of 150 sq ft per man-hour.
- b. Neither mat meets the QMR service life of 1000 coverages of a 50,000-lb single-wheel load with tire-inflation pressure of 250 psi when placed on a 4.0-CBR subgrade.

c. Both mats fell below the QMR coefficient of friction range of 0.4 to 0.8 on a wet surface.

d. Both mats exceeded the technical requirements for 6061-T6 alloy stipulated in reference 11.

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Table 1

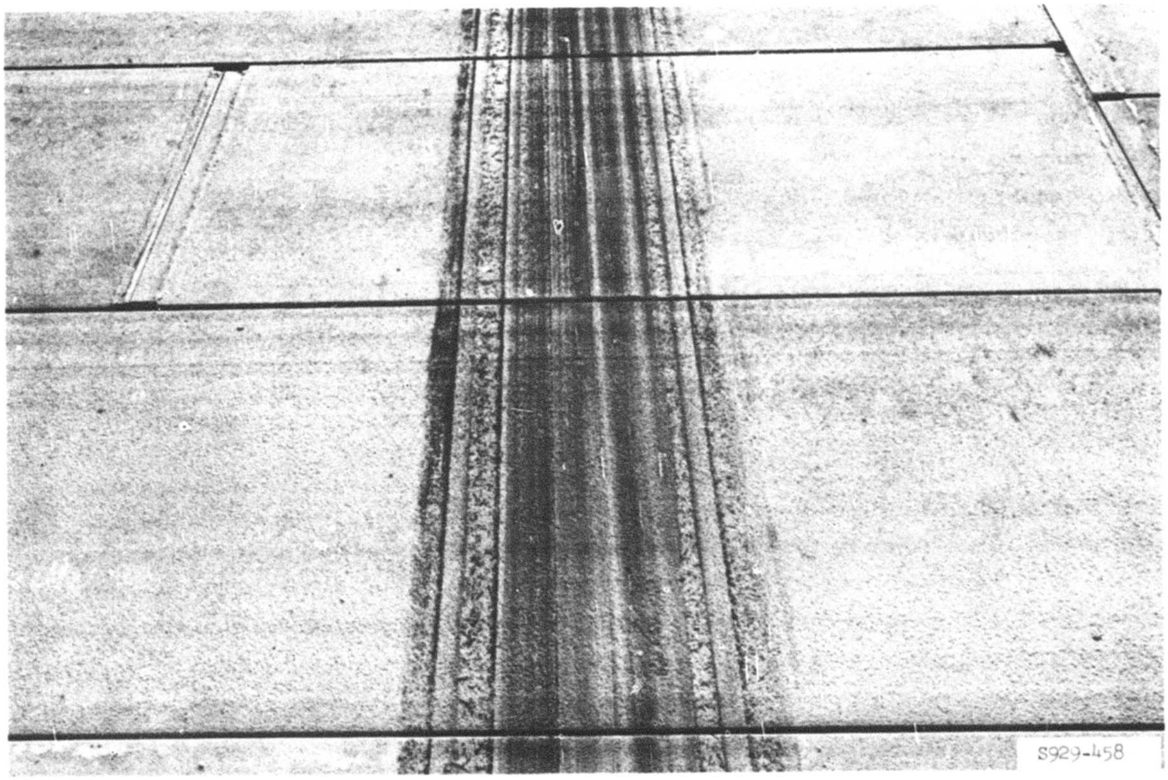
Summary of CBR, Water Content, and Dry Density Data

Mat Type	No. of Coverages	Depth in.	CBR	Rated CBR	Water Content %	Dry Density lb/cu ft
XM20	0	0	3.6		31.6	86.1
		6	3.5		31.6	86.3
		12	3.8		31.9	84.5
		Average	3.6		31.7	85.6
		0	3.4		31.7	84.4
		6	3.6		32.3	85.1
		12	3.4		32.6	84.8
	400	Average	3.5	3.6	32.2	84.8
		0	3.8		32.0	85.9
		6	3.6		32.1	86.7
		12	3.6		33.3	85.3
		Average	3.7		32.5	86.0
		0	3.8		31.6	85.9
		6	3.7		32.5	86.8
		12	3.7		32.5	86.7
		Average	3.7		32.2	86.5
XM20E1	0	0	3.7		27.8	90.3
		6	4.4		27.1	88.7
		12	3.5		29.9	87.9
		Average	3.9		28.3	89.0
		0	3.8		27.7	89.2
		6	4.0		28.9	89.1
		12	4.2		29.5	89.1
	500	Average	4.0	4.6	28.7	89.1
		0	7.0		26.4	92.4
		6	5.0		28.4	89.7
		12	4.0		28.6	90.8
		Average	5.3		27.8	91.0
		0	7.0		25.2	94.8
		6	4.2		27.8	88.4
		12	3.9		29.3	89.5
		Average	5.0		27.4	90.9
	500 Reprocessed	0	4.1		28.9	88.6
		6	3.9		29.8	89.1
		12	3.0		32.7	85.4
		Average	3.7		30.5	87.7
		0	4.0		30.2	87.2
		6	3.3		30.1	88.9
		12	3.0		32.2	86.1
	780	Average	3.4	3.9	30.8	87.4
		0	5.0		29.0	90.4
		6	4.5		28.6	90.3
		12	3.2		31.1	87.7
		Average	4.2		29.6	89.5
		0	4.3		29.0	90.4
		6	4.7		29.4	89.7
		12	3.4		31.5	86.4
		Average	4.1		30.0	88.8

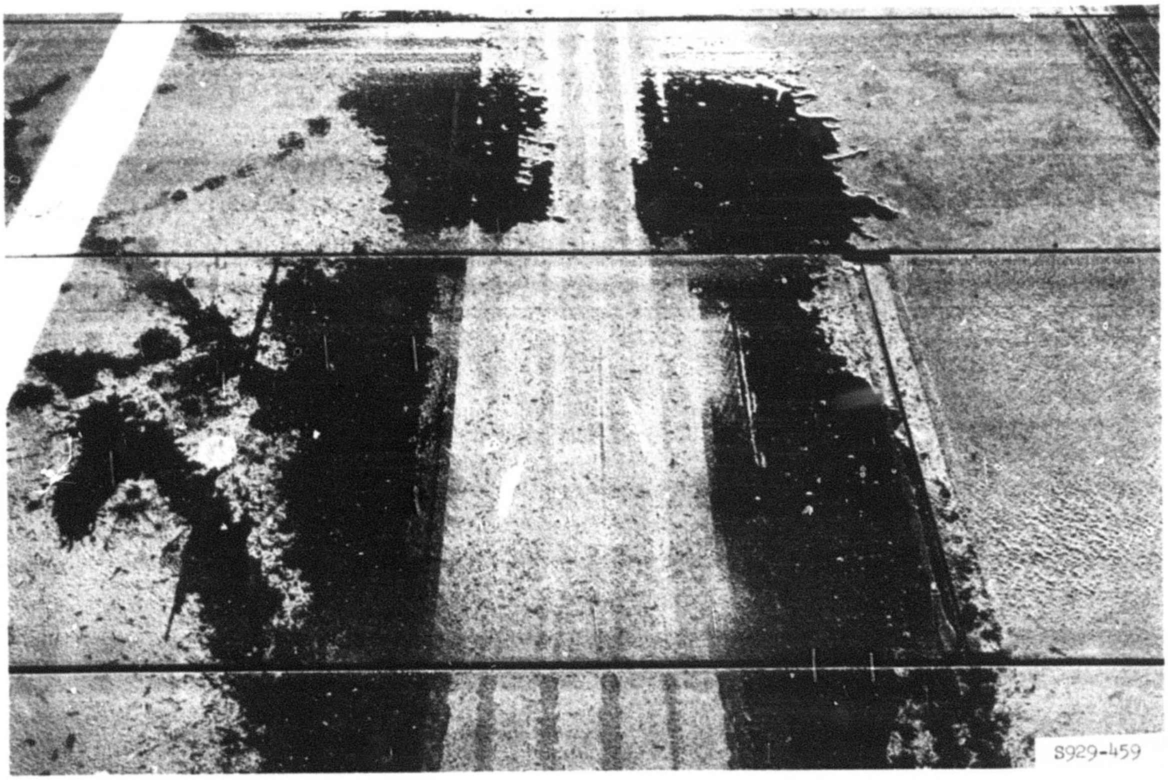
Table 2

Results of Standard Tension Tests of XM20 and XM20E1 Mats

Mat Type	Location of Specimen	Gage Length in.	Width in.	Thickness in.	Area sq in.	Ultimate Load lb	Stress psi	Final Gage Length in.	Percent Elongation in 2 in.
XM20	Top surfacing	2.0	0.499	0.118	0.058	3000	51,724	2.313	16
			0.501	0.117	0.058	3100	53,448	2.281	14
			0.500	0.119	0.059	3100	52,542	2.313	16
	Vertical rib	2.0	0.500	0.145	0.072	3000	41,667	2.344	17
			0.501	0.143	0.071	2900	40,845	2.375	19
			0.503	0.144	0.072	2950	40,972	2.375	19
	Bottom surfacing	2.0	0.500	0.129	0.064	2700	42,188	2.313	16
			0.501	0.128	0.064	2650	41,406	2.313	16
			0.501	0.130	0.065	2650	40,769	2.281	14
						Average	45,062	Average	16
XM20E1	Top surfacing	2.0	0.500	0.126	0.063	2825	44,841	2.250	13
			0.499	0.126	0.062	2850	45,968	2.240	12
			0.500	0.126	0.063	2825	44,841	2.240	12
	Vertical rib	2.0	0.501	0.149	0.074	3250	43,919	2.250	13
			0.500	0.137	0.068	2950	43,382	2.250	13
			0.501	0.139	0.069	3025	43,841	2.280	14
	Bottom surfacing	2.0	0.501	0.126	0.063	2850	45,238	2.240	12
			0.500	0.130	0.065	2900	44,615	2.200	10
			0.500	0.127	0.063	2900	46,03[illegible]	2.200	10
						Average	44,742	Average	12



a. Dry surface; note pieces of rubber torn from tire



b. Wet surface

Photo 1. Skid marks on XM20E1 mat caused by skidding of locked wheel

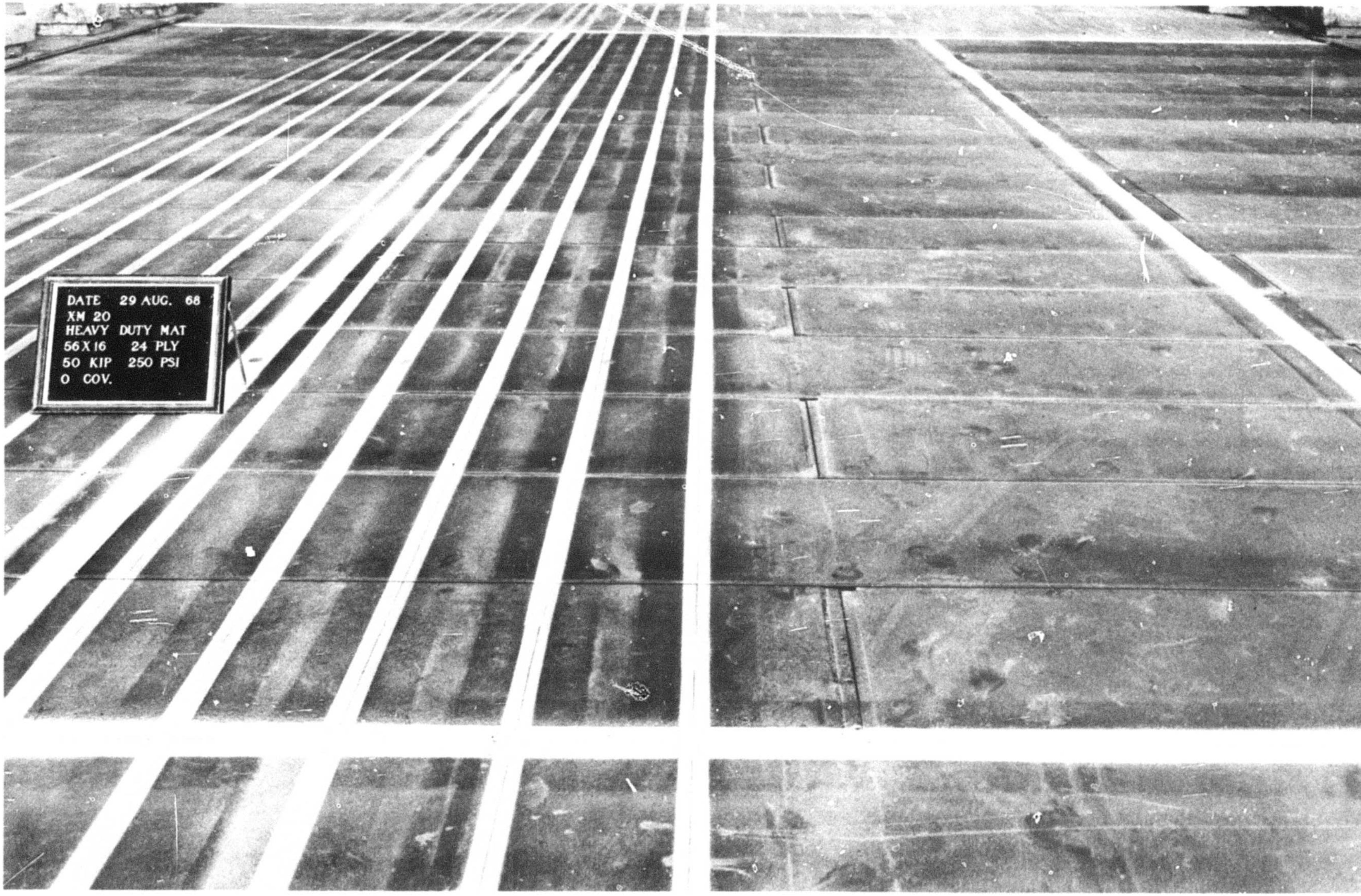


Photo 2. XM20 test section prior to traffic

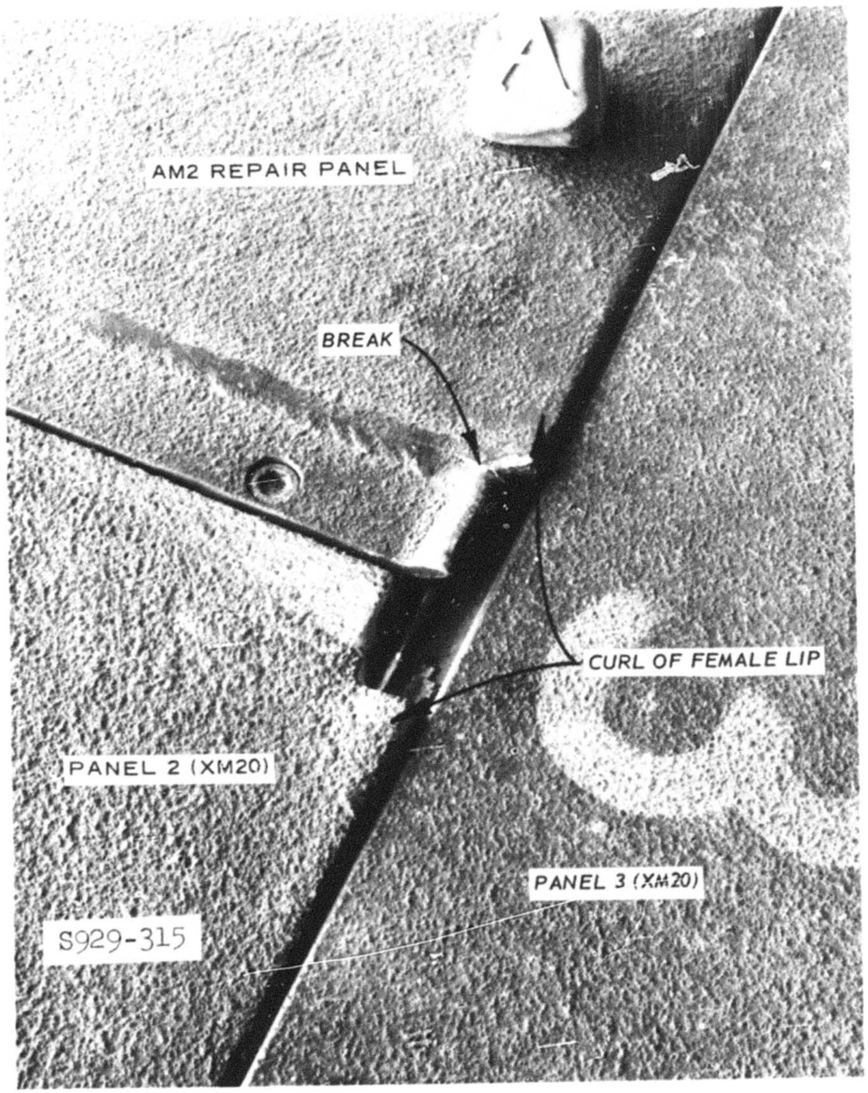


Photo 3. Break in weld between extrusion and underlap connector of AM2 repair panel after 22 coverages

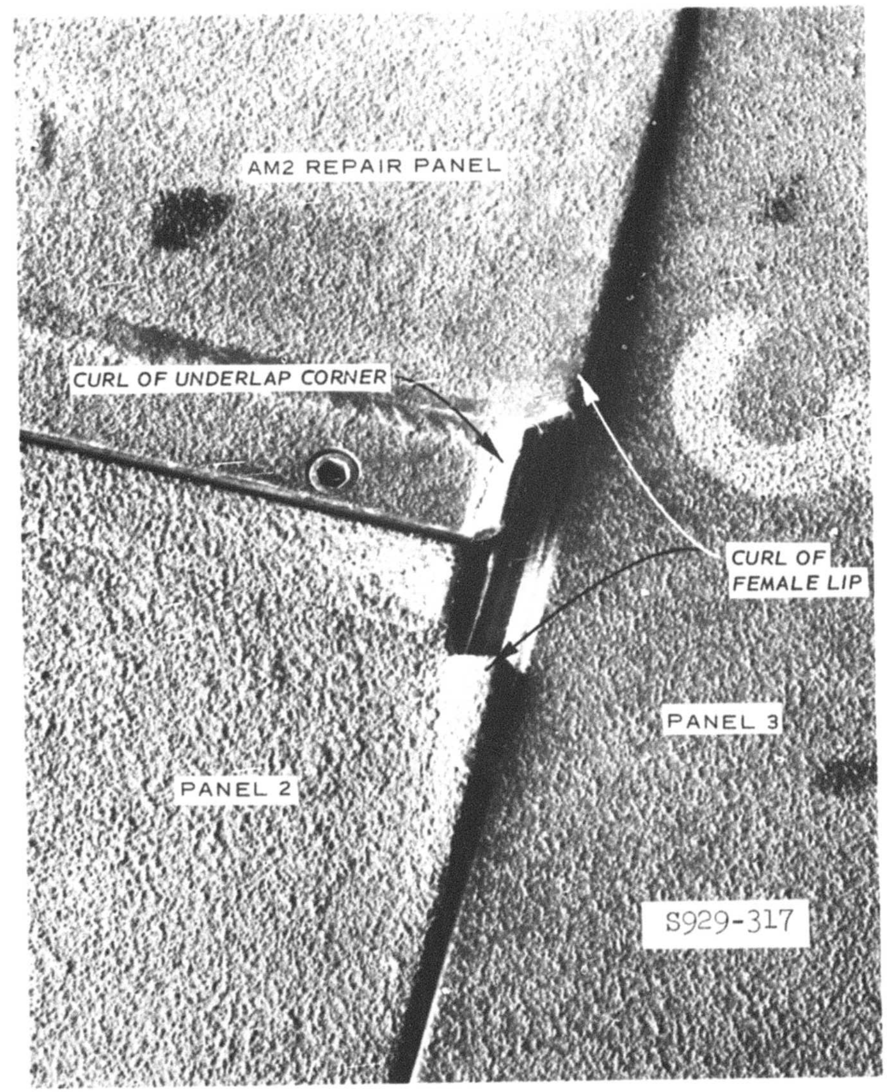


Photo 4. Failure of AM2 repair panel at the female/underlap corner after 124 coverages

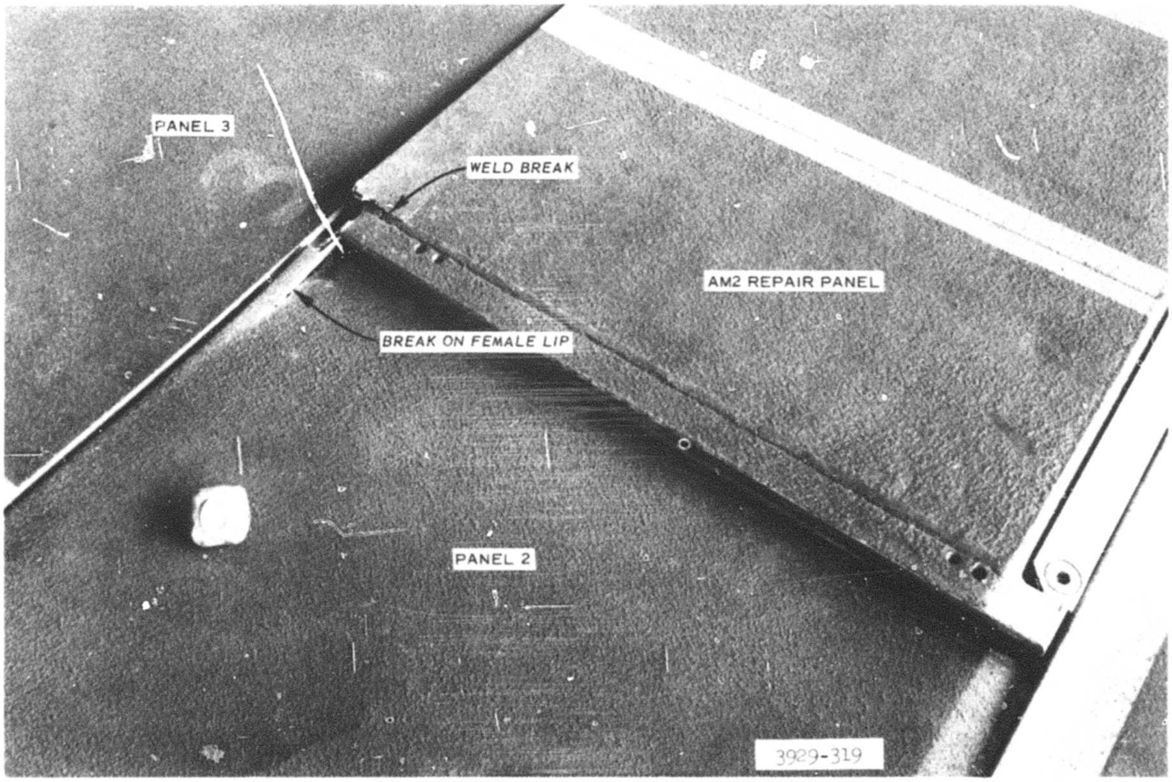


Photo 5. Split in female lip of XM20 panel 2 after 200 coverages

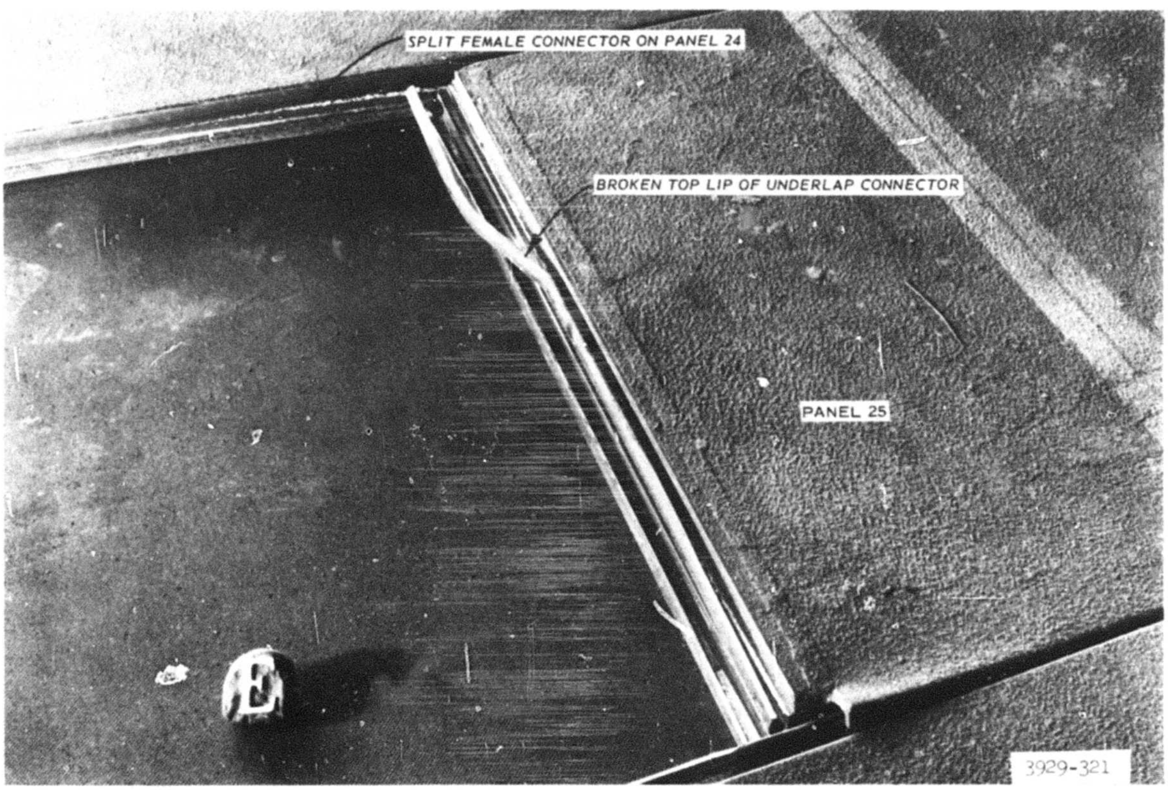


Photo 6. Failure of XM20 panel 25 after 276 coverages

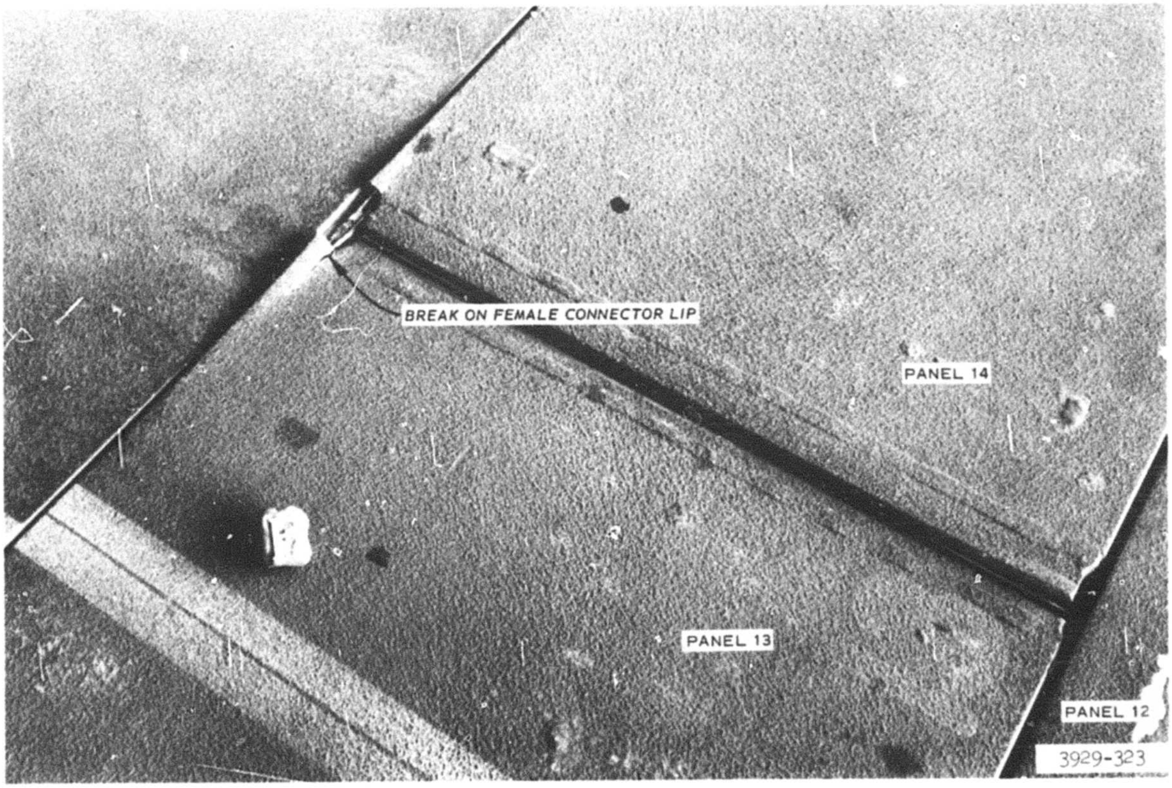


Photo 7. Failure of XM20 panel 13 after 370 coverages

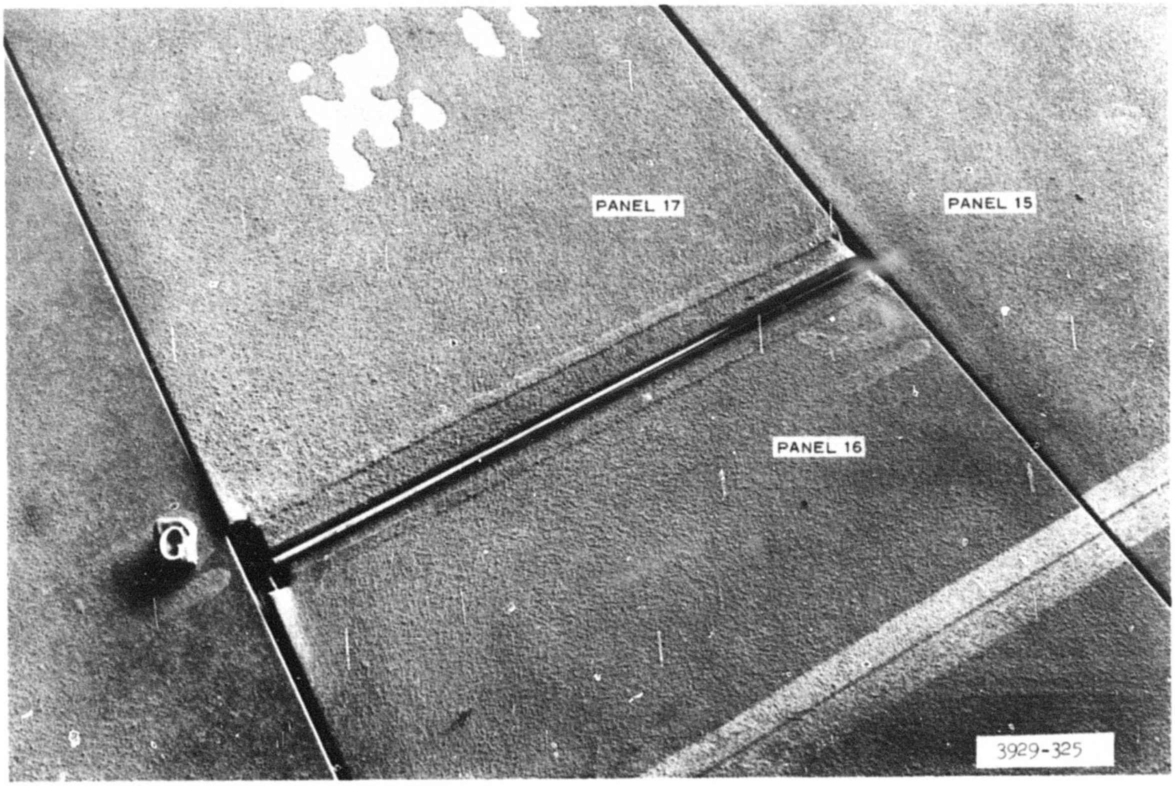


Photo 8. Failure of XM20 panel 16 after 384 coverages

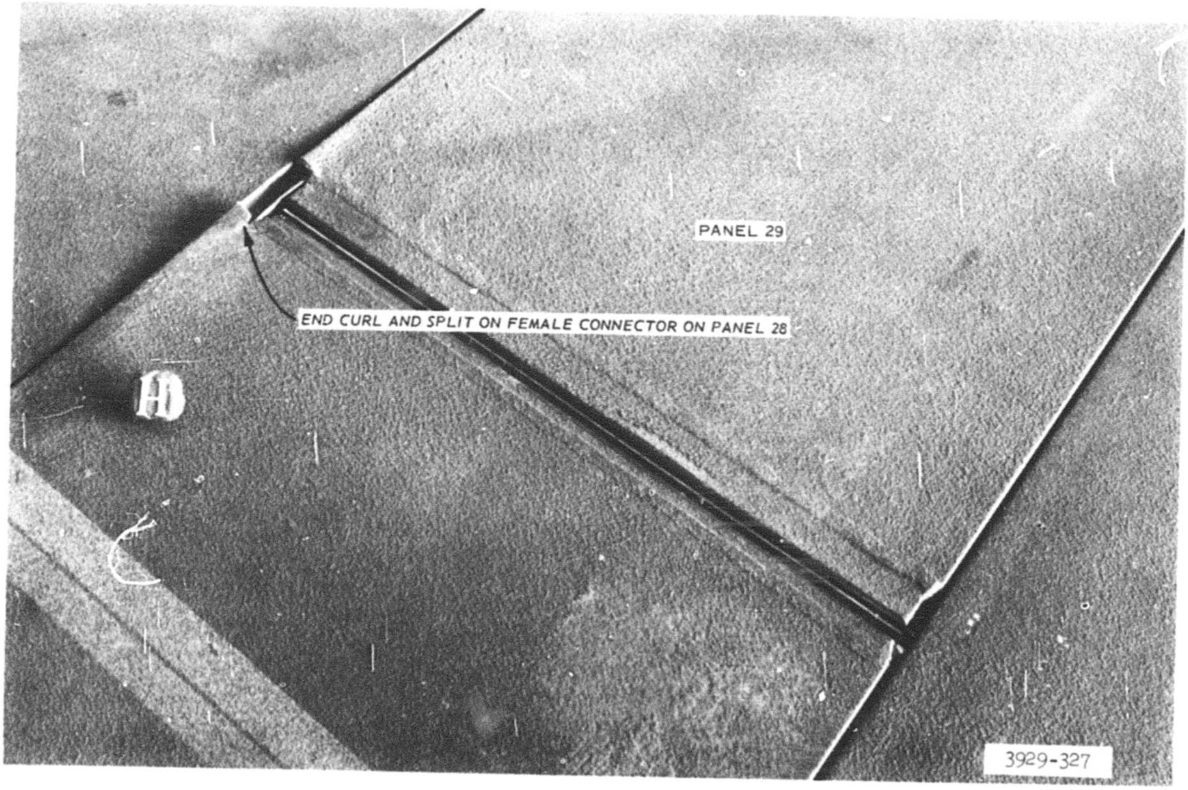


Photo 9. Failure of XM20 panel 28 after 400 coverages

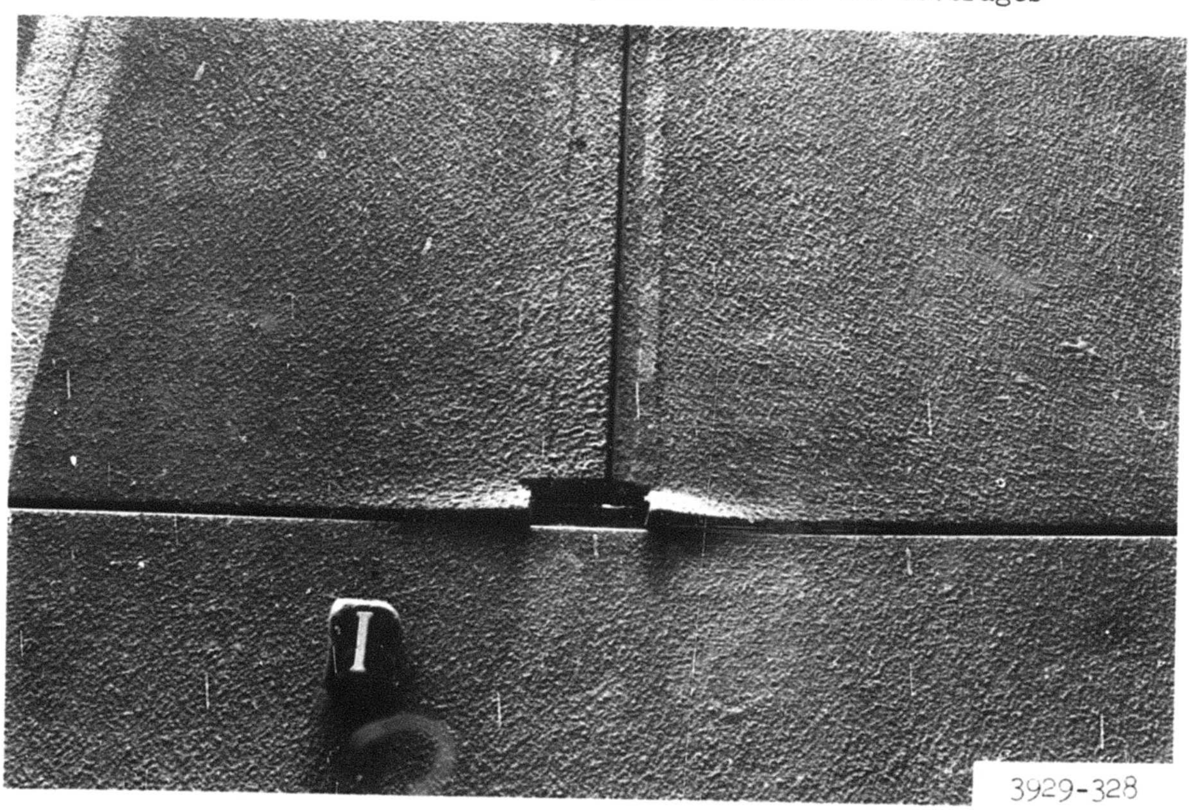


Photo 10. Typical female connector curl on XM20 mat after 400 coverages

Photo 11. XM20 test section at completion of testing. Section considered failed

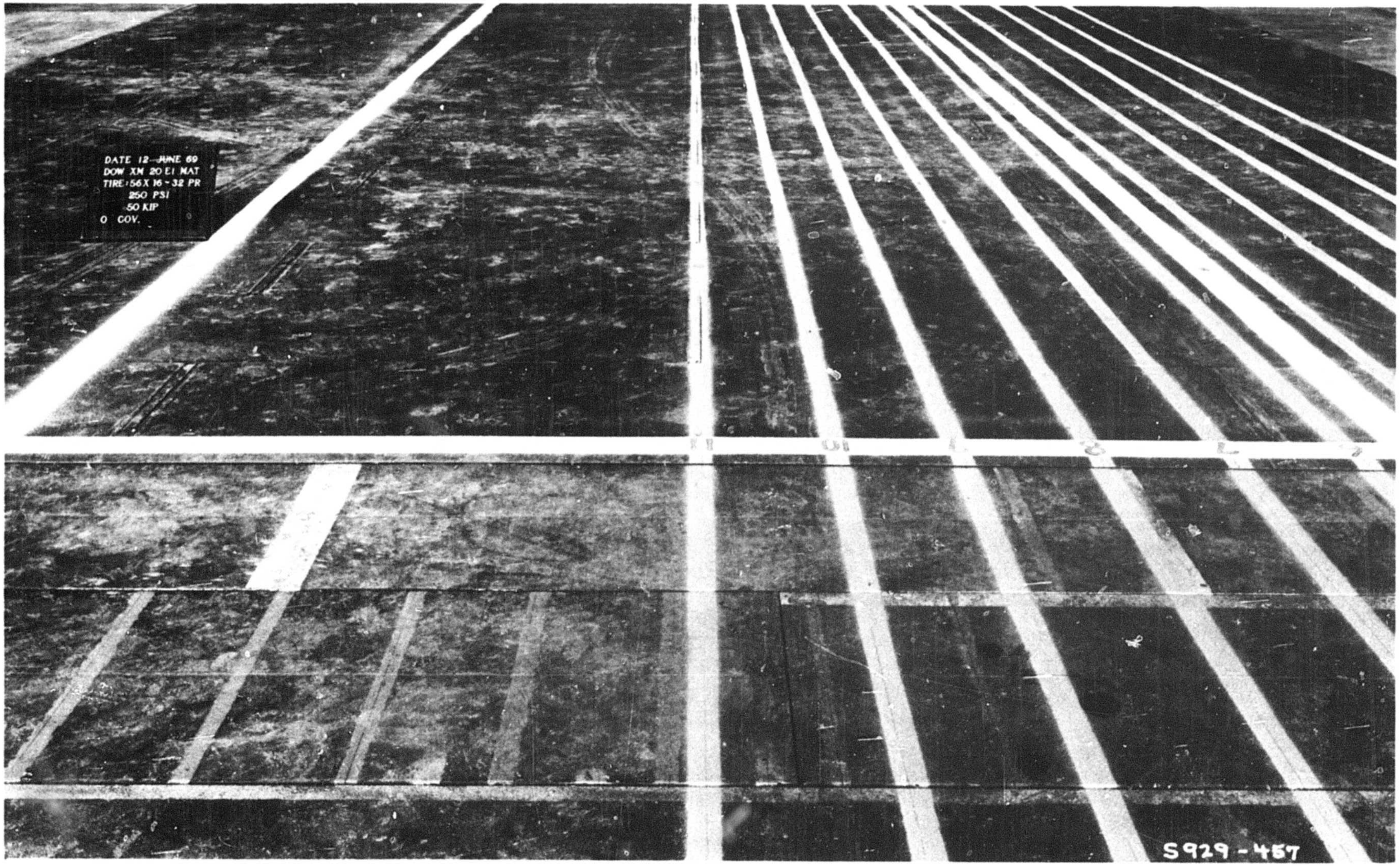


Photo 12. XM20E1 test section prior to traffic

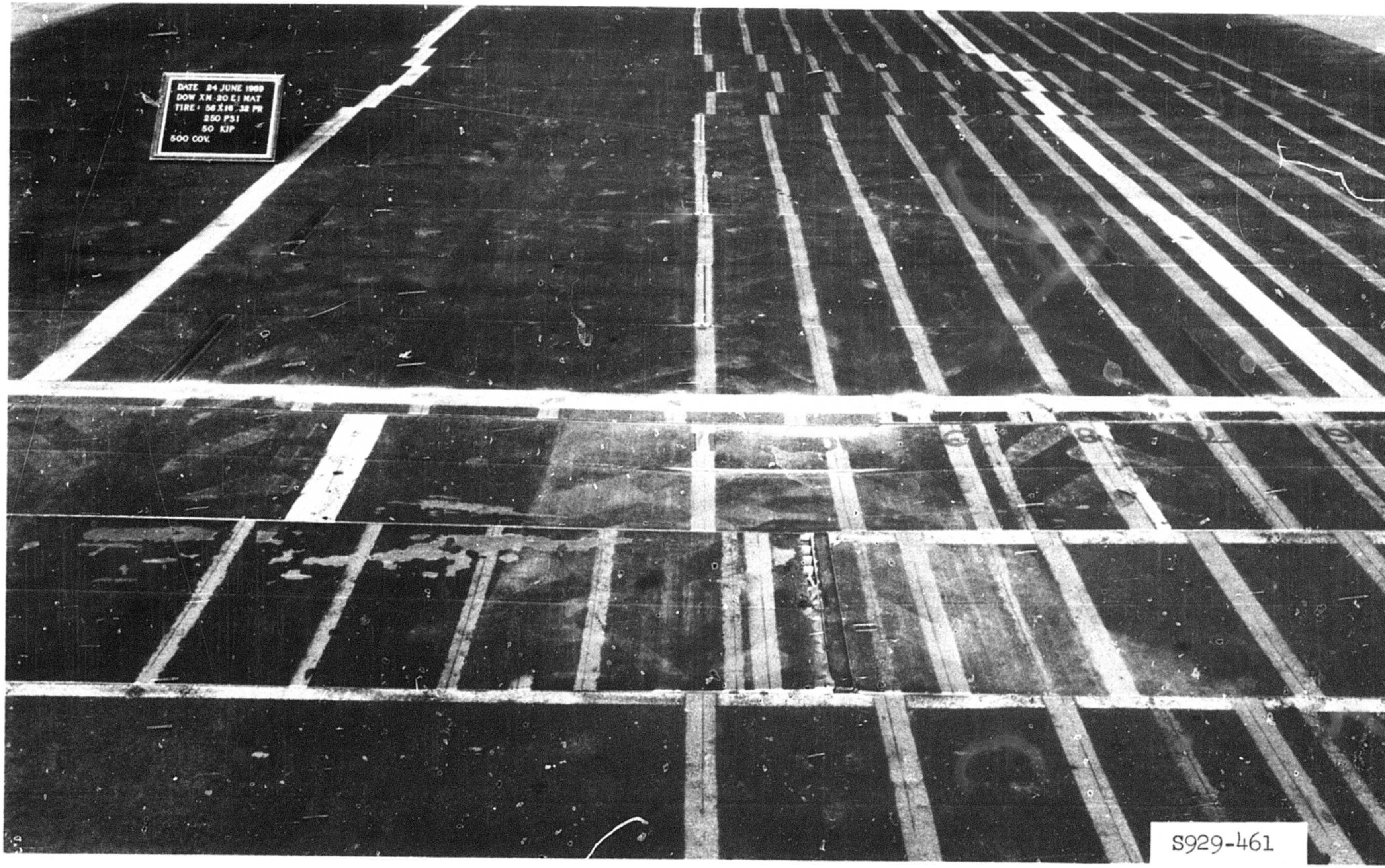


Photo 13. XM20E1 test section after 500 coverages

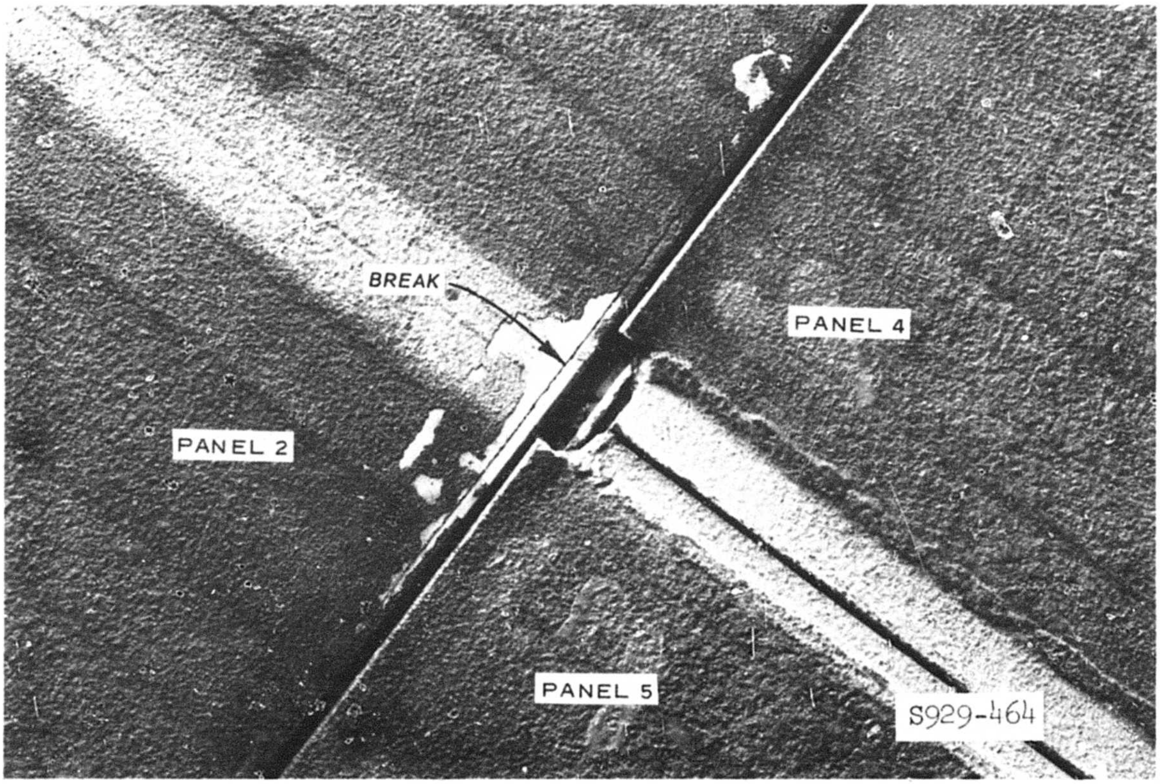


Photo 14. Break on surface of XM20E1 panel 2 after 630 coverages

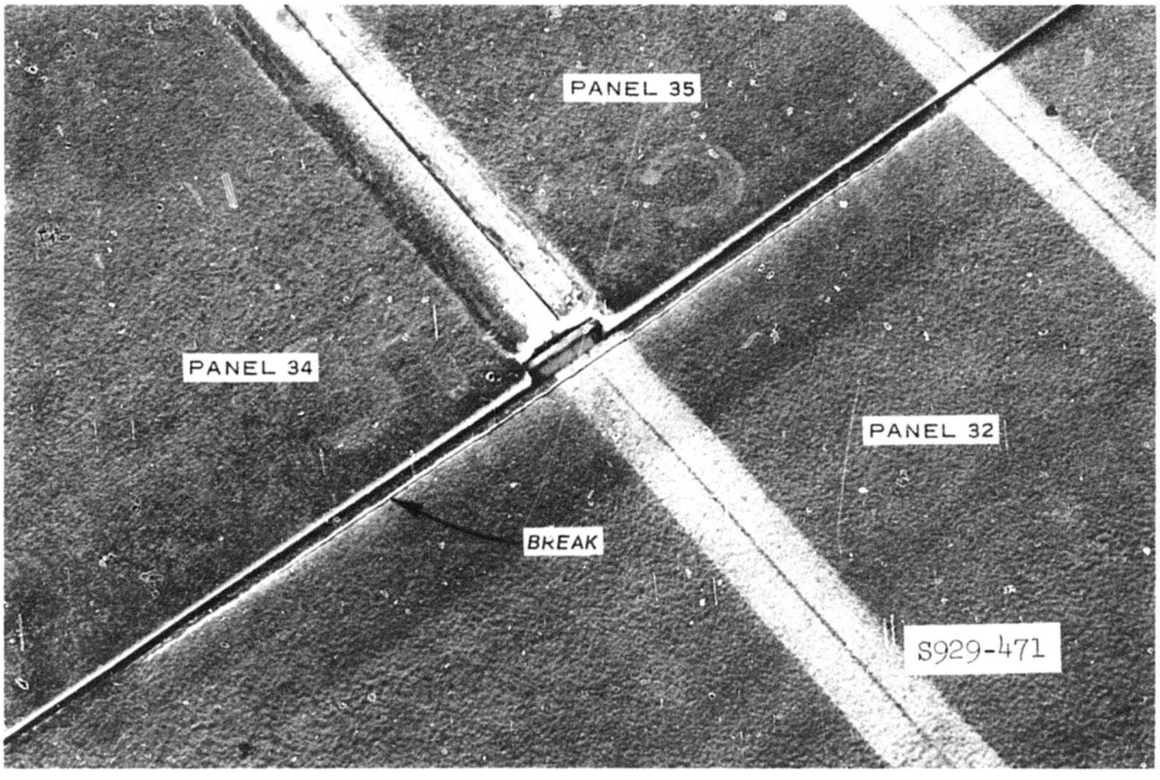


Photo 15. Break on surface of XM20E1 panel 32 after 730 coverages

Photo 16. XM20E1 test section at completion of testing. Section considered failed

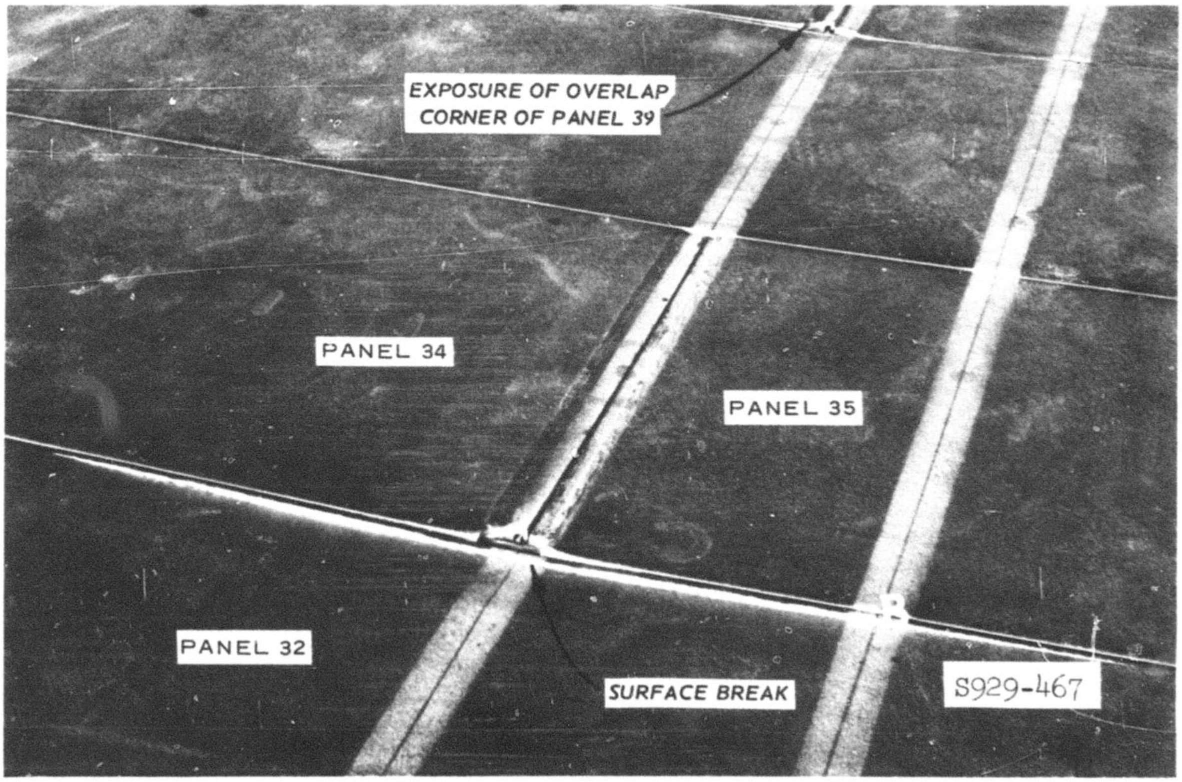


Photo 17. Break on surface of XM20E1 panel 32
after 780 coverages (failure)

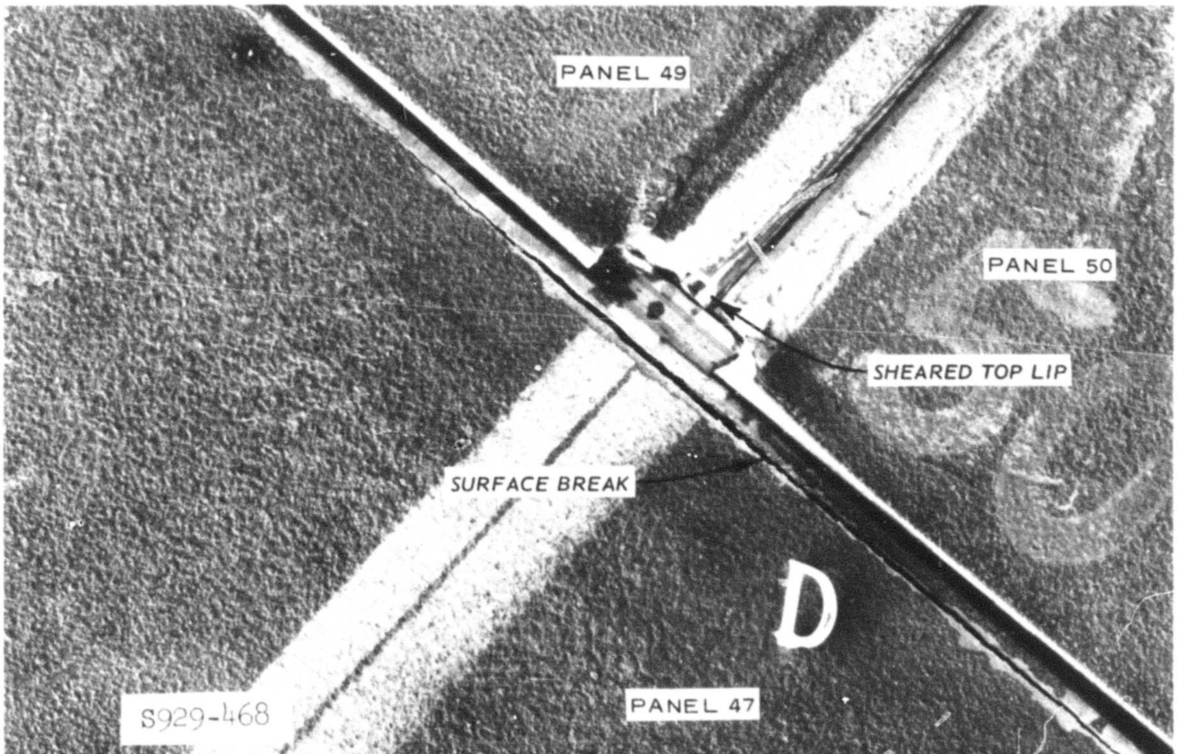


Photo 18. Break on surface of XM20E1 panel 47 and sheared underlap
top lip of XM20E1 panel 50 after 780 coverages (failure)

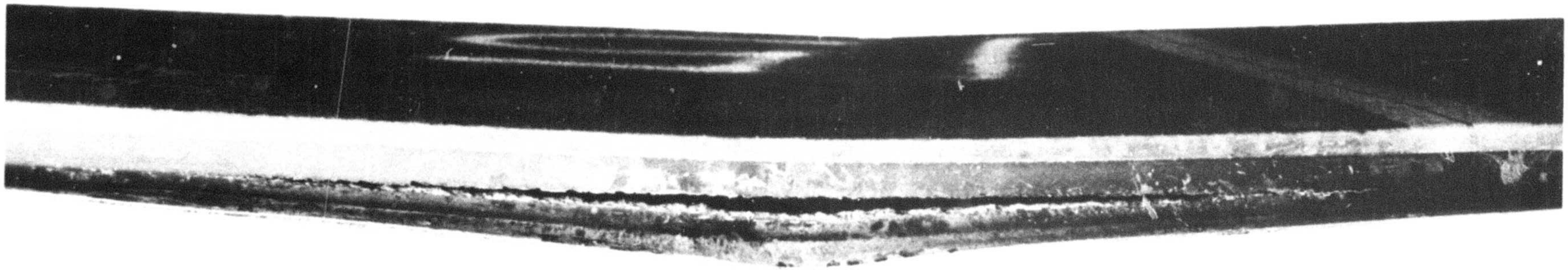


Photo 19. Typical split at flange of female connector at center of XM20 panel

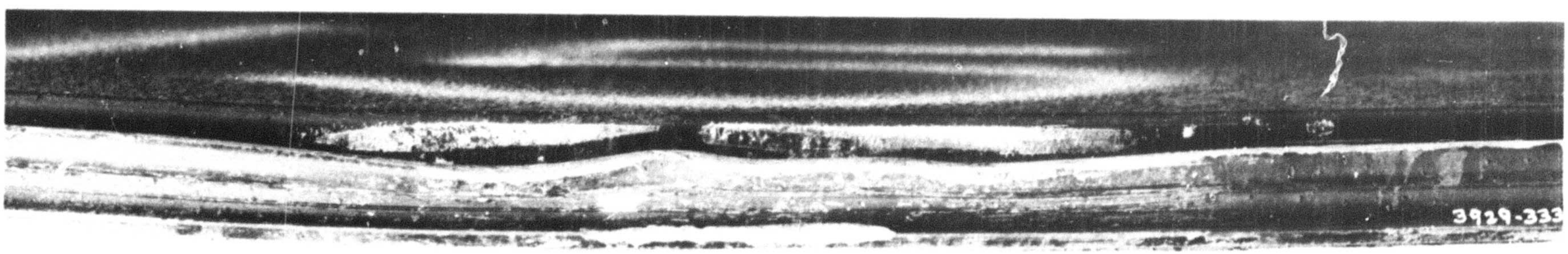
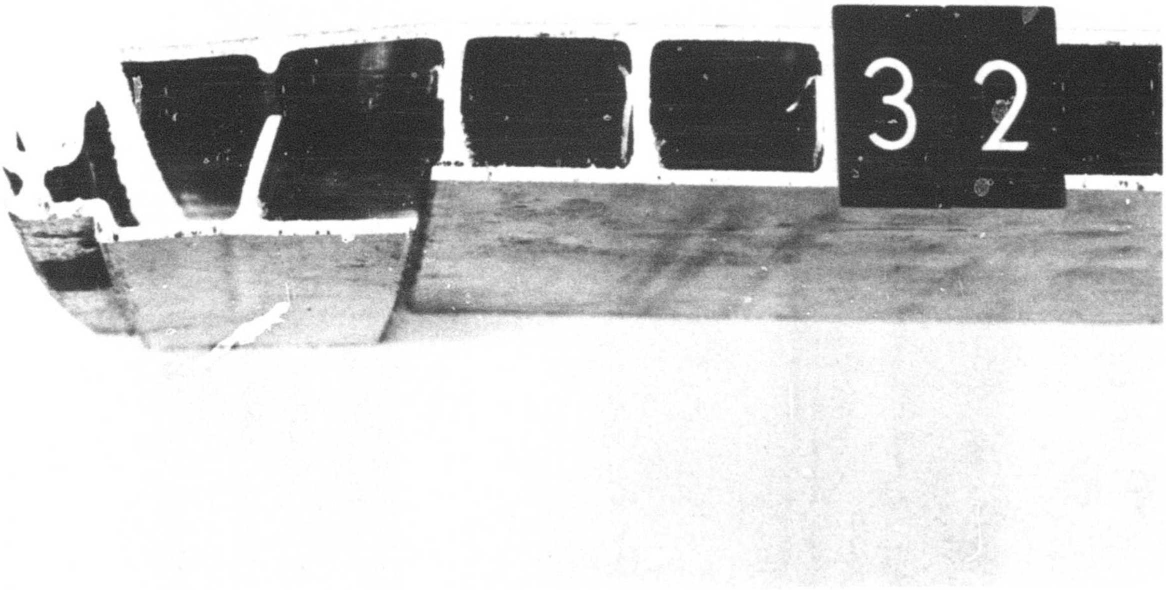
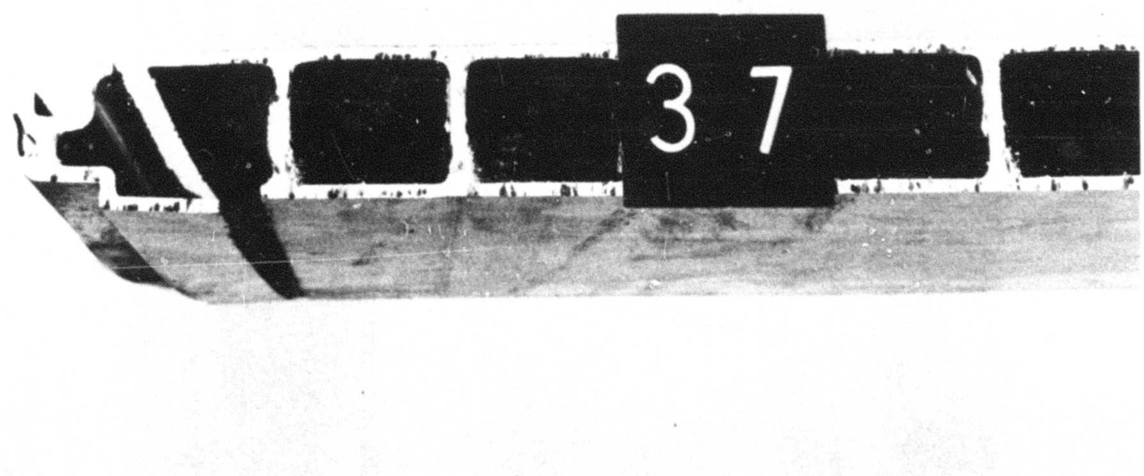


Photo 20. Typical metal wear and mar on male connector of XM20 panel



a. Panel 32



b. Panel 37

Photo 21. Cross sections of XM20E1 panels showing top and bottom surface failures

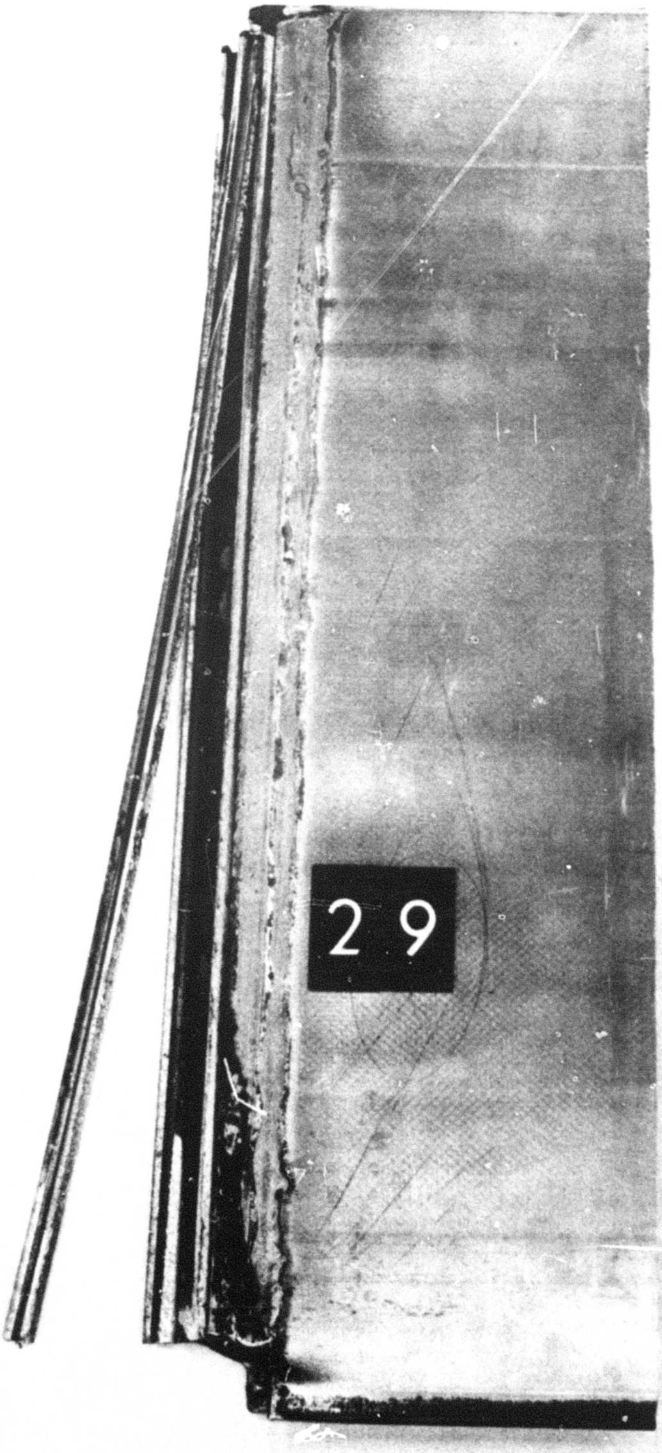
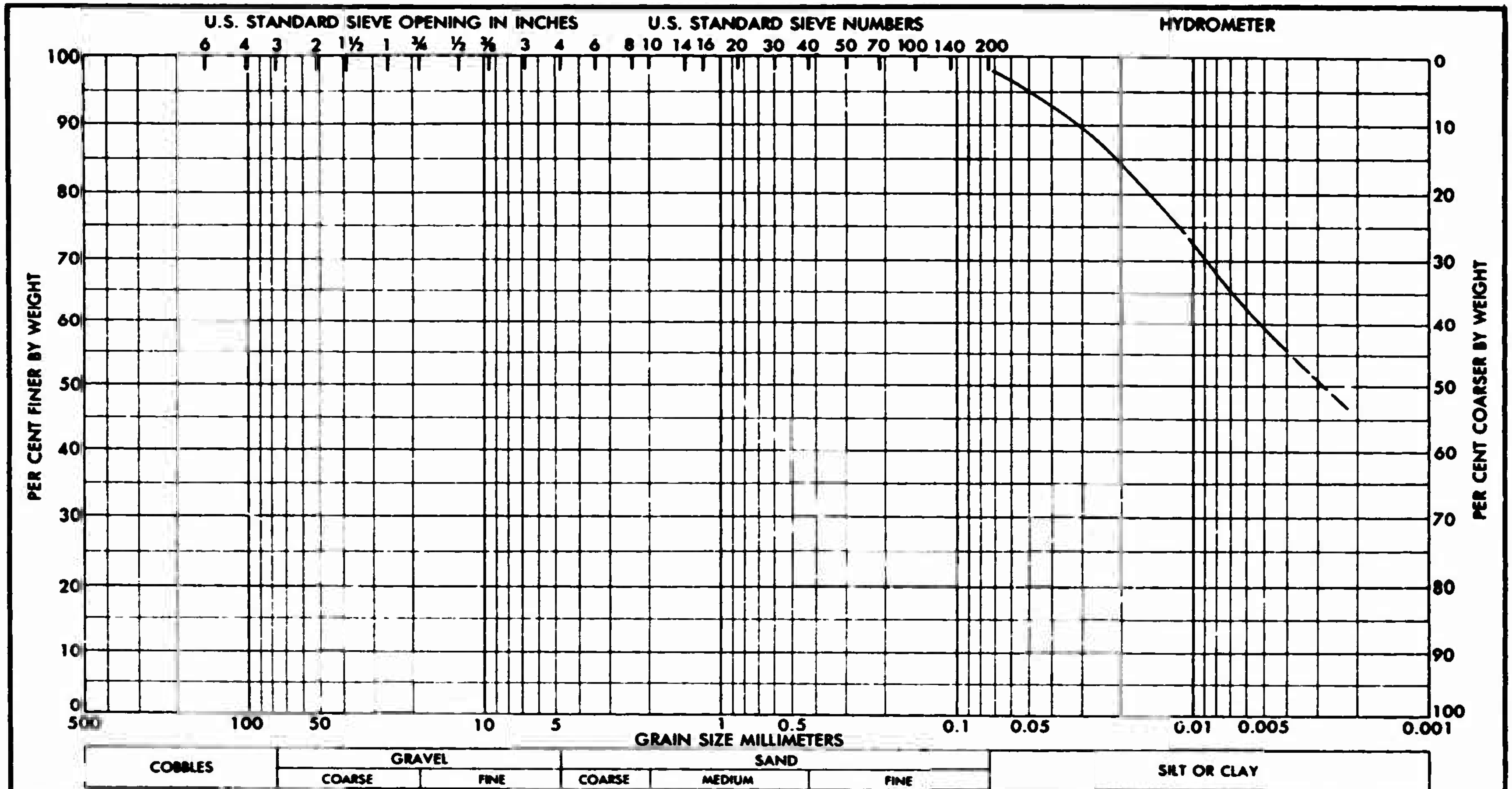


Photo 22. Bottom lip of overlap connector sheared on XM20E1 panel



SAMPLE NO.	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
		CLAY (CH)		58	25	33

CLASSIFICATION DATA

SUBGRADE SOIL

PLATE 1

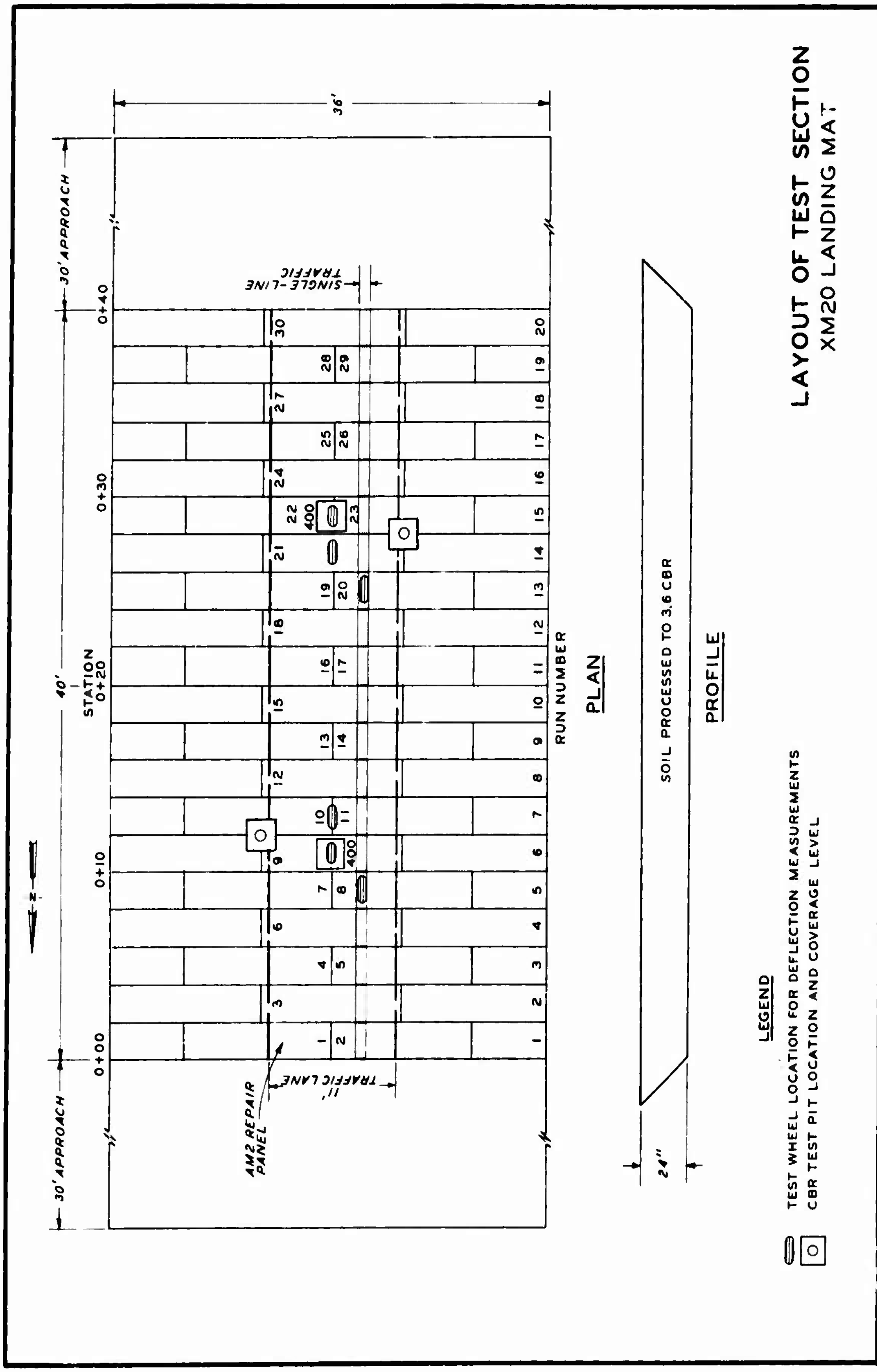
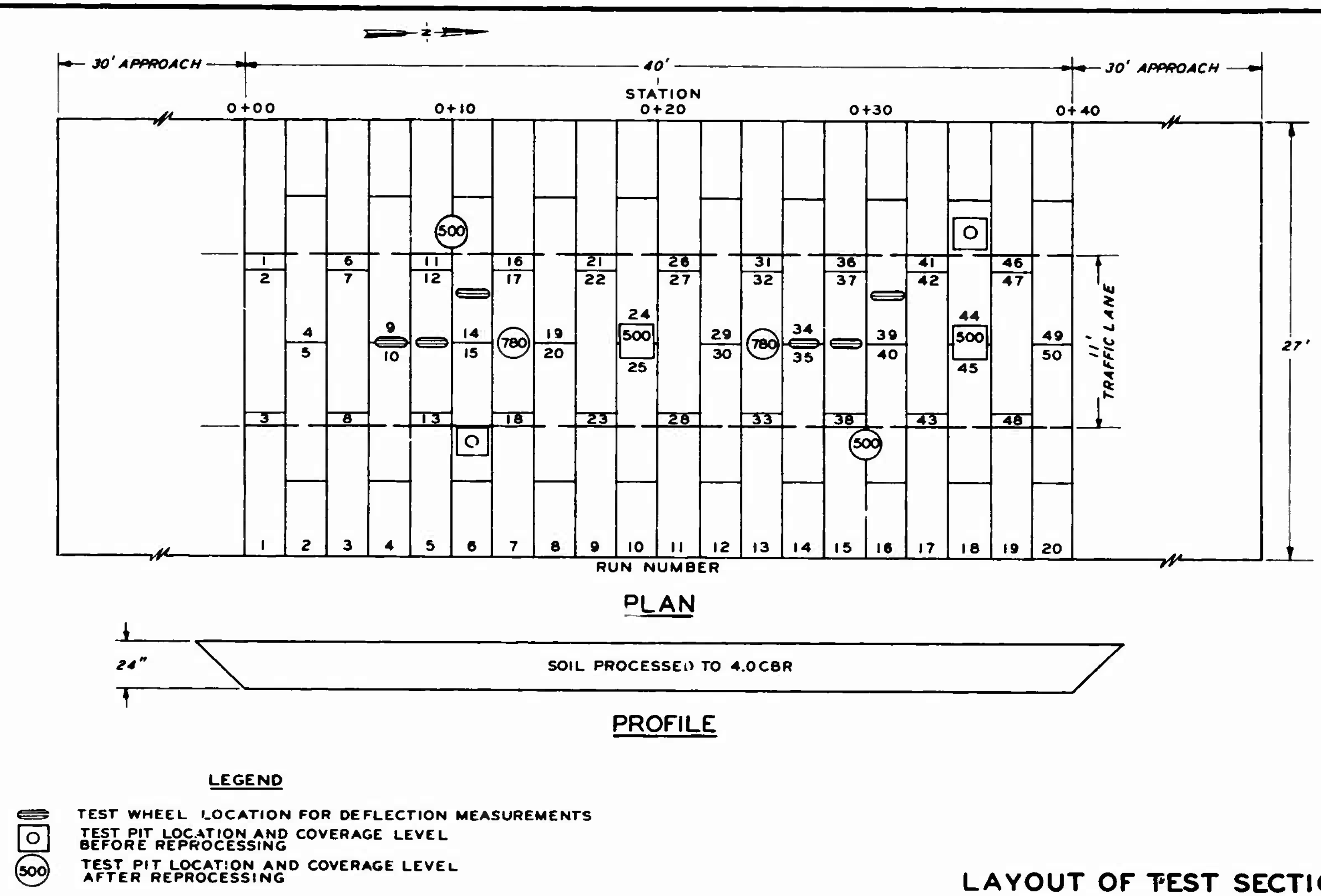
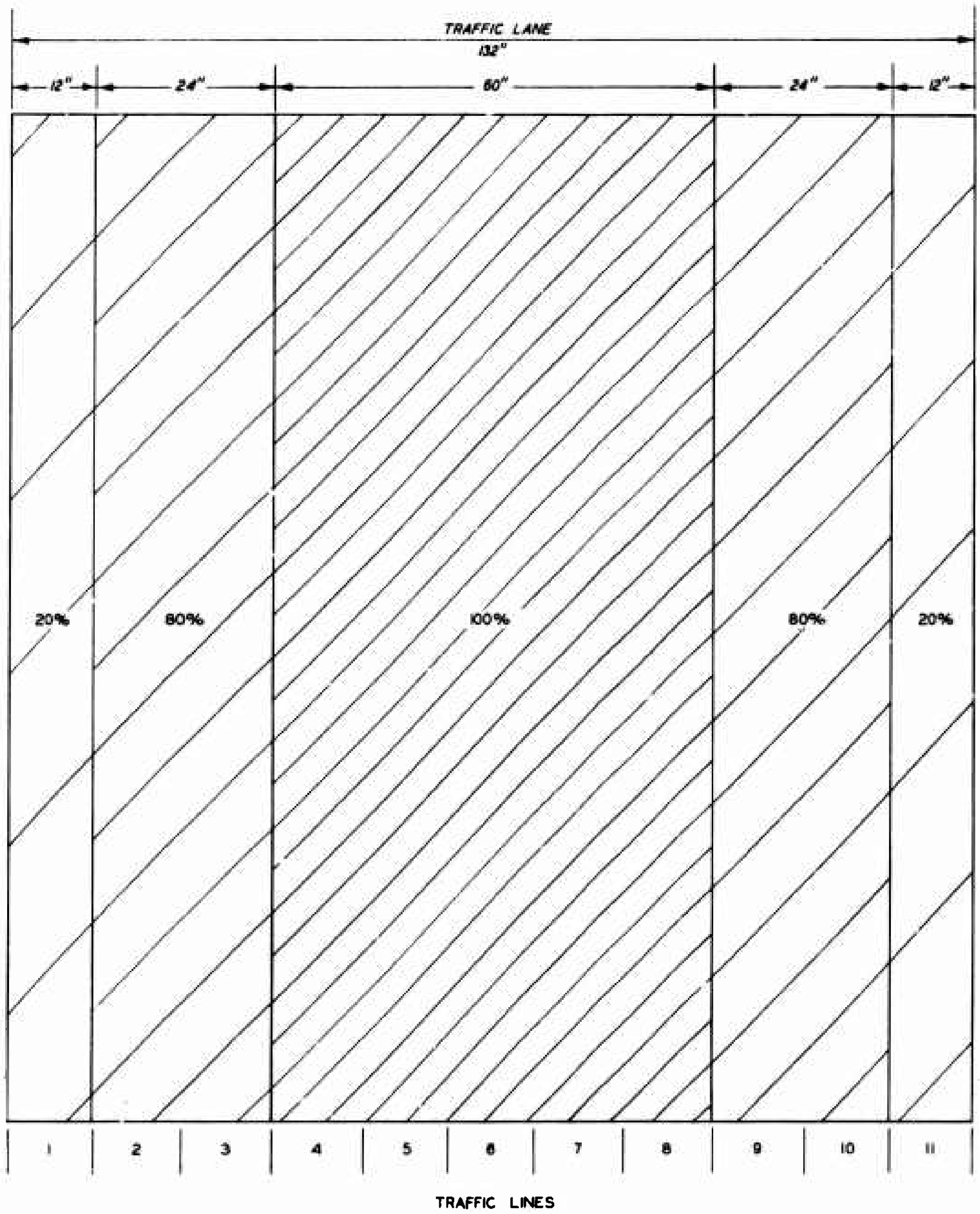

LAYOUT OF TEST SECTION
XM20 LANDING MAT
PLAN
PROFILE
LEGEND
TEST WHEEL LOCATION FOR DEFLECTION MEASUREMENTS
CBR TEST PIT LOCATION AND COVERAGE LEVEL
SOIL PROCESSED TO 3.6 CBR
RUN NUMBER
STATION
0+00
0+10
0+20
0+30
0+40
30' APPROACH
40'
30' APPROACH
36'
24"
11' TRAFFIC LANE
SINGLE-LINE TRAFFIC
AM2 REPAIR PANEL
400
400
N

PLATE 2



LAYOUT OF TEST SECTION
XM20E1 LANDING MAT

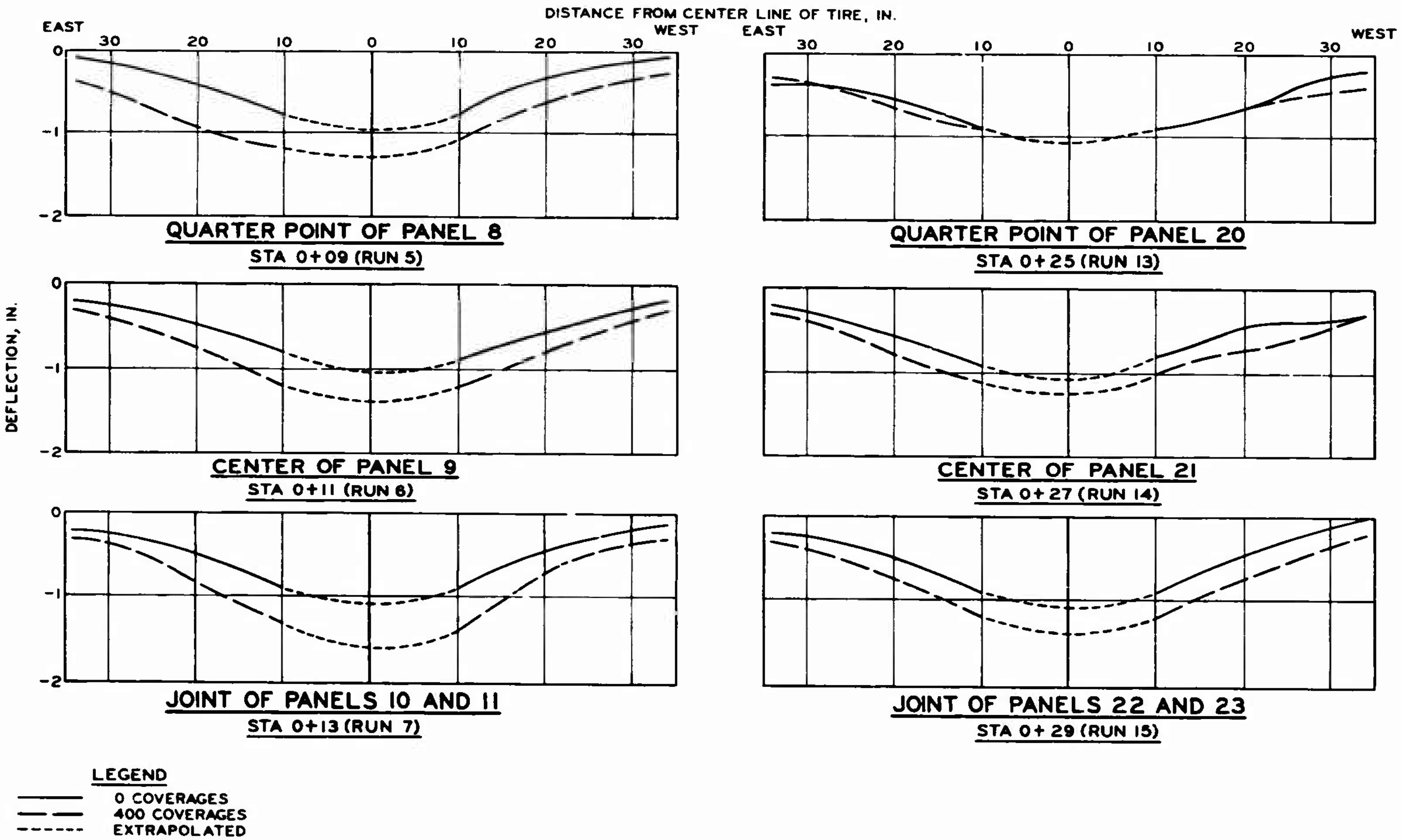


NOTE: EACH PASS IS EQUAL TO A COVERAGE BY A 12-IN.-WIDE LOAD WHEEL OVER EACH TRAFFIC LINE.

TRAFFIC DISTRIBUTION

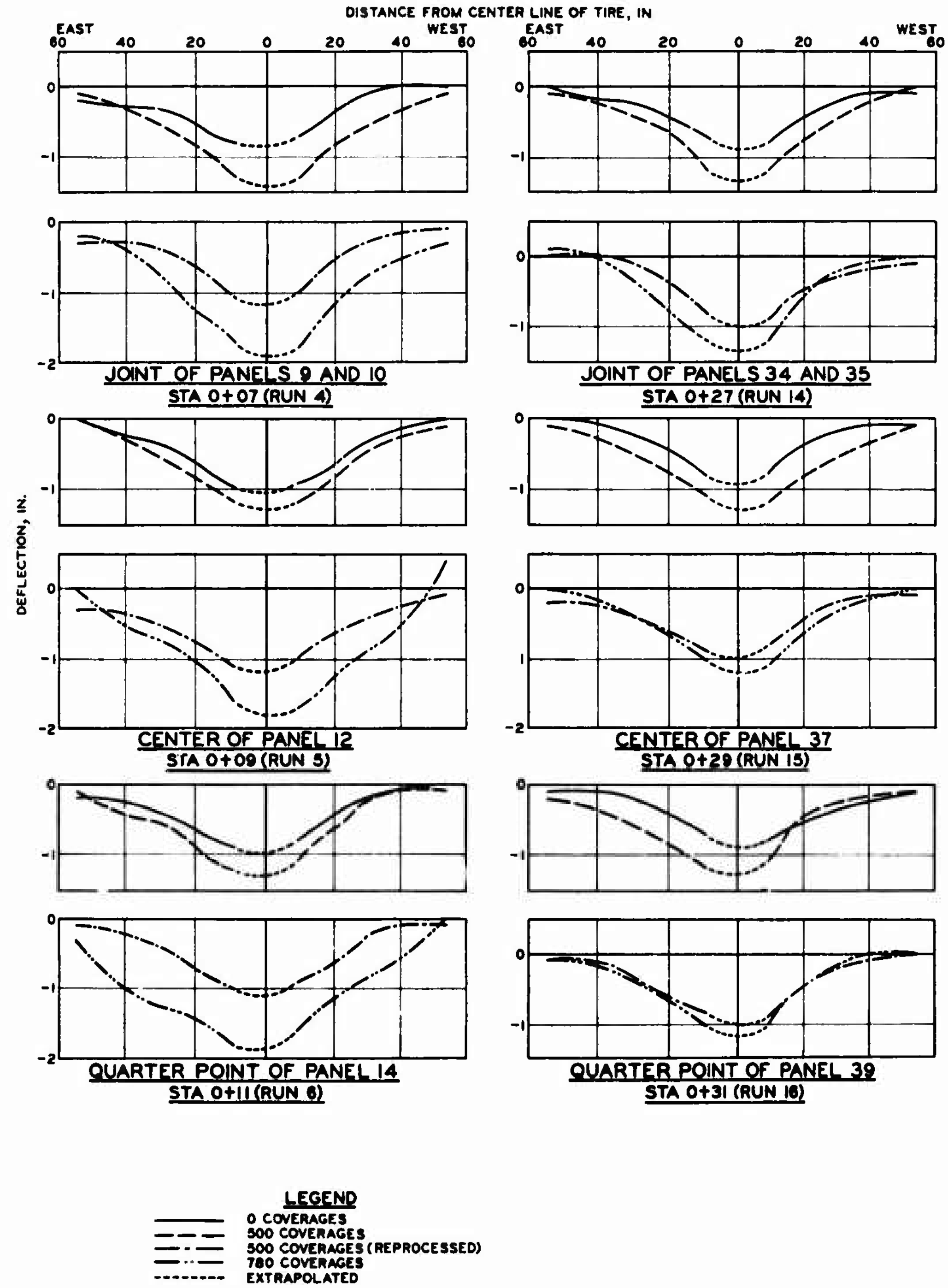
50,000-LB LOAD
250-PSI TIRE PRESSURE

PLATE 4



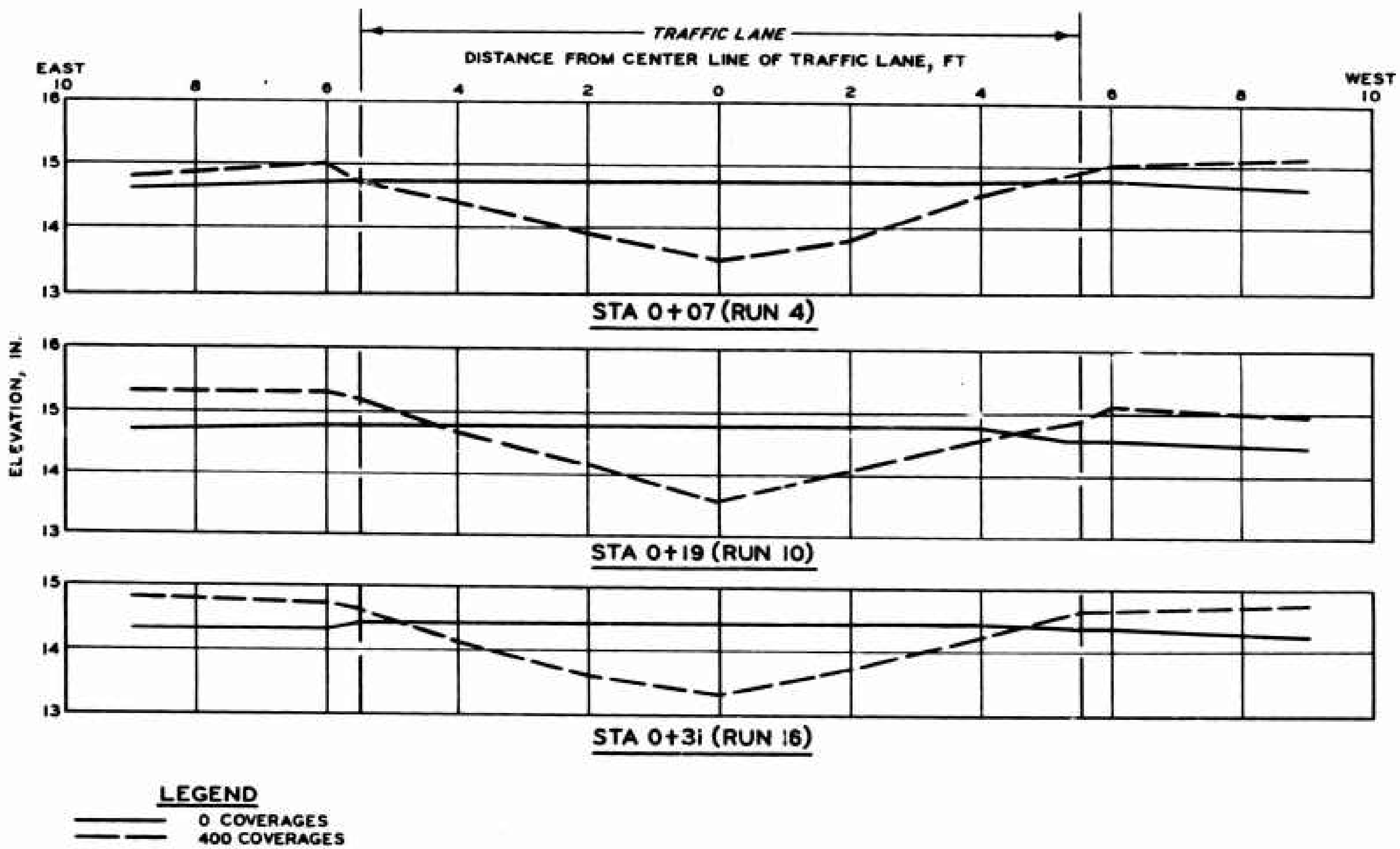
STATIC DEFLECTIONS
XM20 MAT

PLATE 5

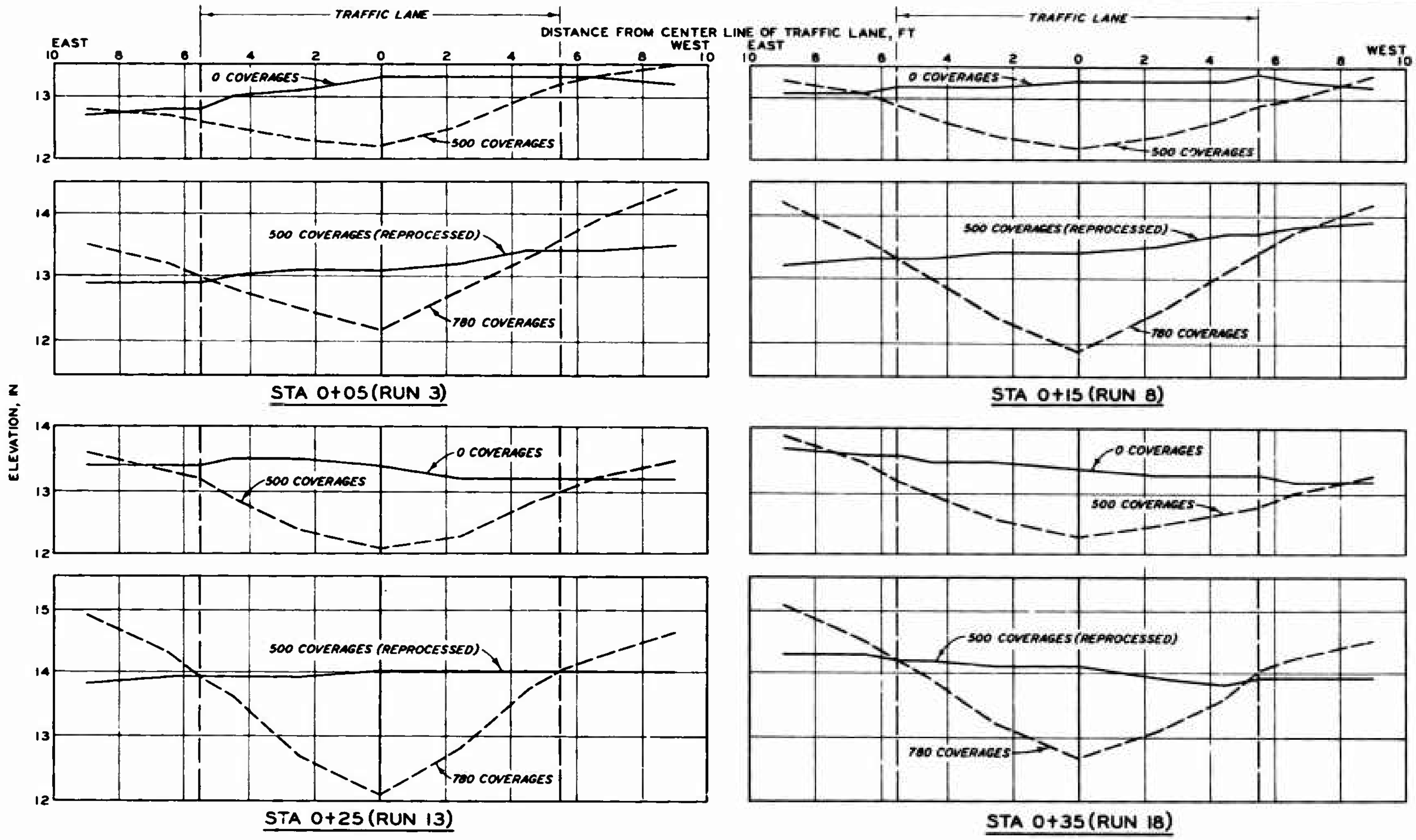


STATIC DEFLECTIONS
XM20E1 MAT

PLATE 6

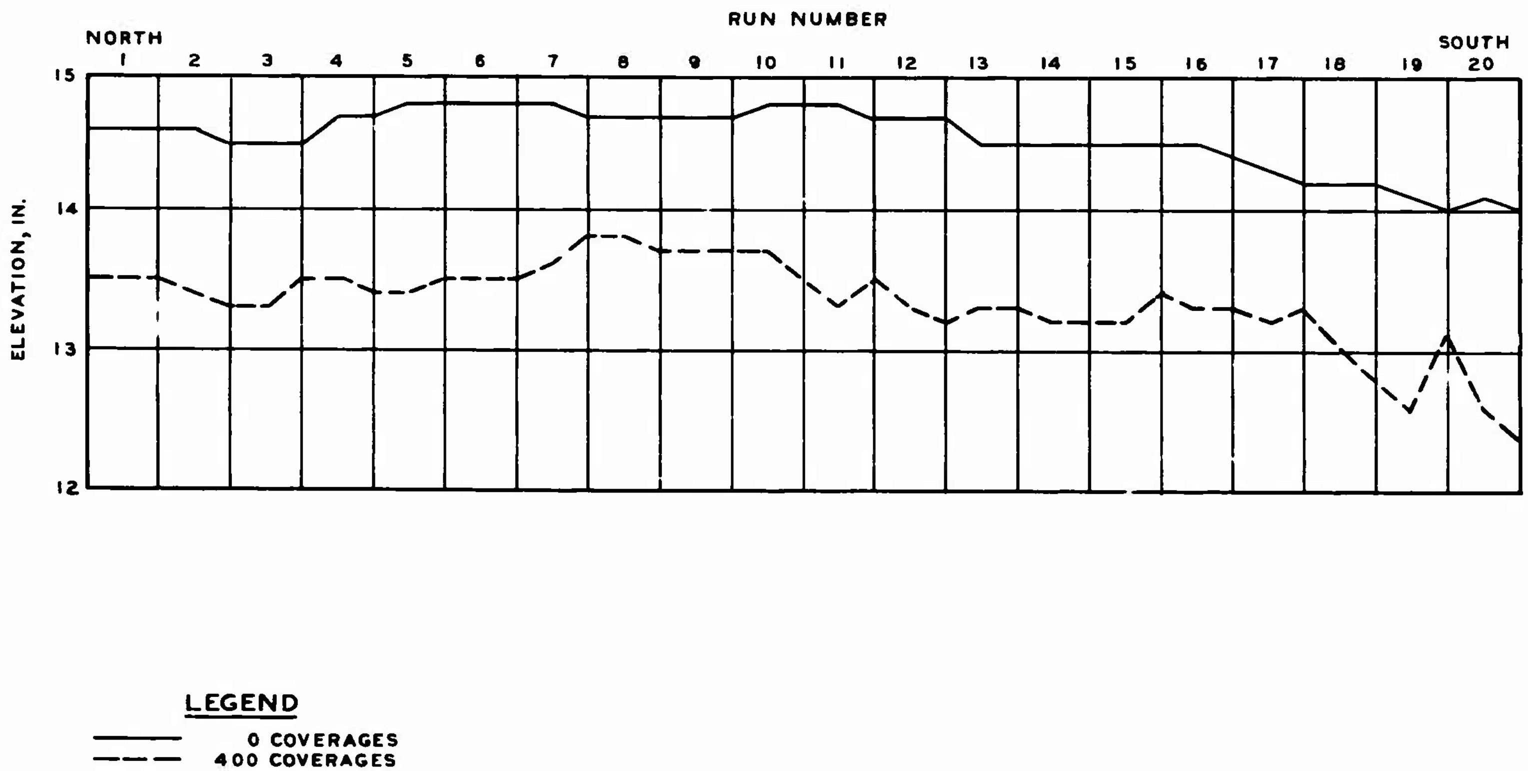


CROSS SECTIONS
XM20 MAT



CROSS SECTIONS
XM20E1 MAT

PLATE 8



PERMANENT DEFORMATION PROFILES

CENTER LINE OF TRAFFIC LANE XM20 MAT

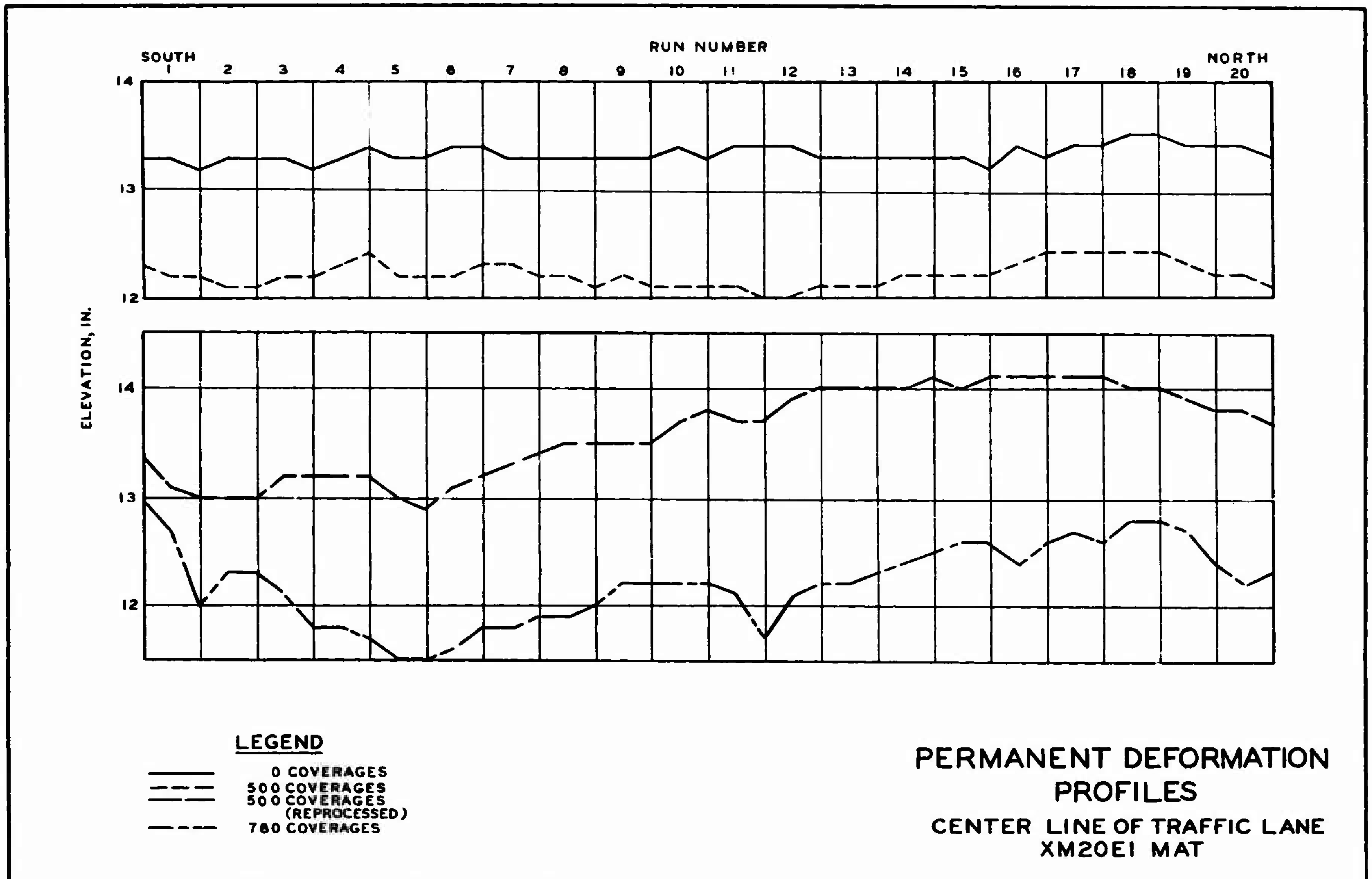
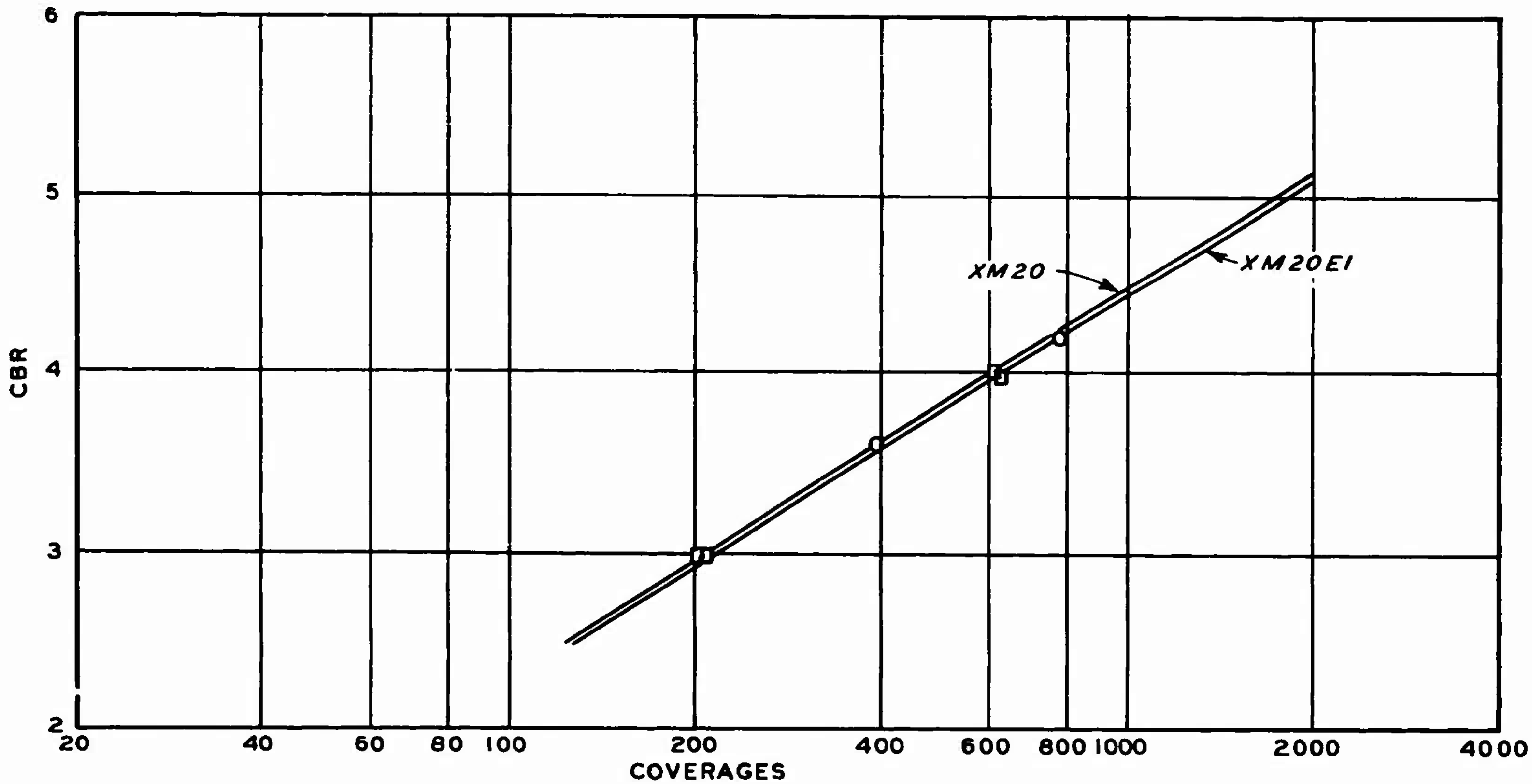

RUN NUMBER
SOUTH
NORTH
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
ELEVATION, IN.
14 13 12
14 13 12
LEGEND
0 COVERAGES
500 COVERAGES
500 COVERAGES (REPROCESSED)
780 COVERAGES
PERMANENT DEFORMATION PROFILES
CENTER LINE OF TRAFFIC LANE
XM20E1 MAT

PLATE 10



LEGEND

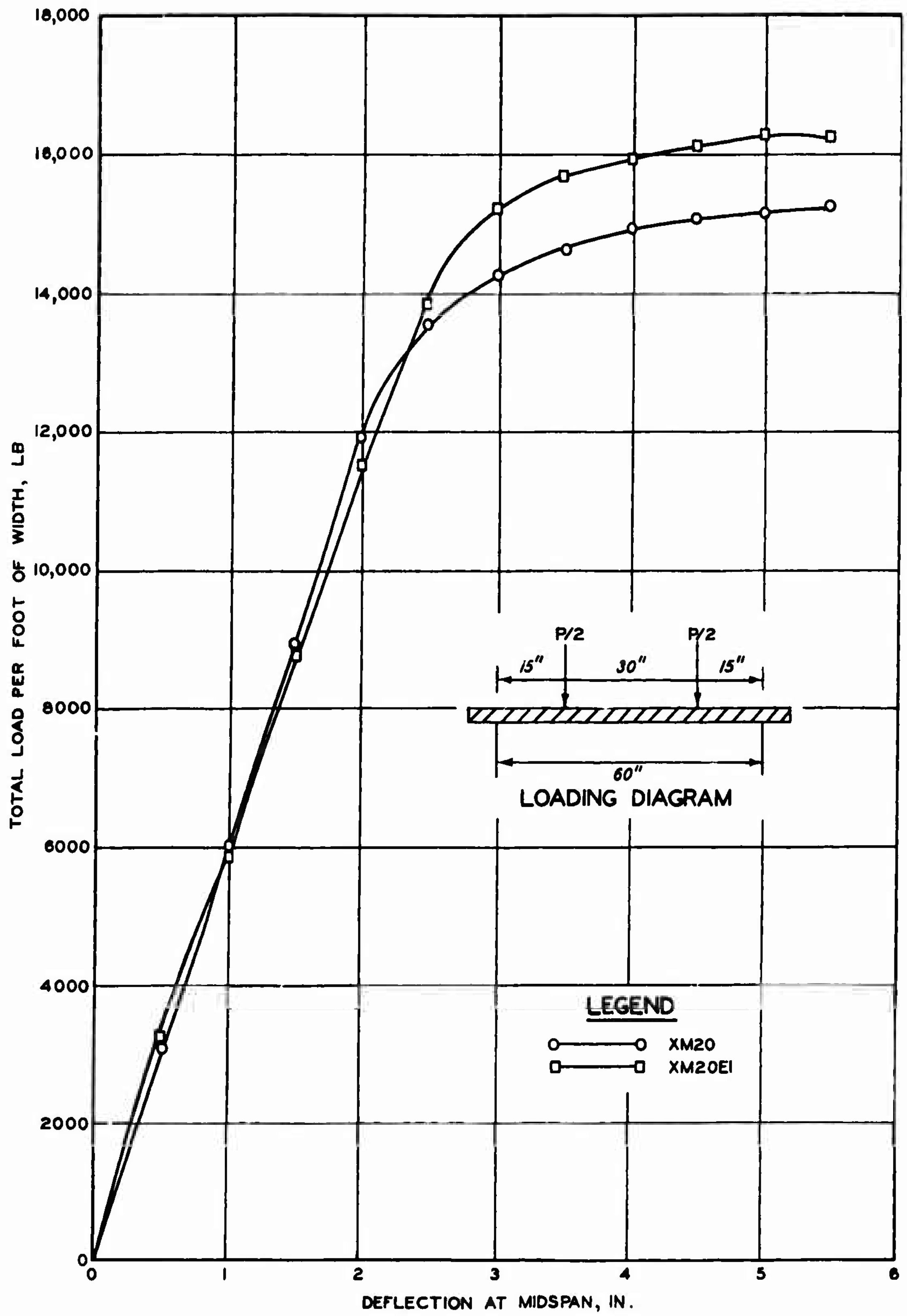
O SECTION FAILURE POINT
□ COMPUTED POINT

NOTE : BASED ON CBR EQUATION FROM REFERENCE 10.

STRENGTH EVALUATION OF XM20 AND XM20E1 LANDING MATS

50,000-LB SINGLE-WHEEL LOAD
250-PSI TIRE PRESSURE

PLATE 11



60-IN. BEAM TESTS

XM20 AND XM20E1 MATS

PLATE 12